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16. ABSTRACT

This report presents a comprehensive discussion of the data handling process in Colorado's decentralized vehicle emissions inspection/maintenance (I/M) program. The purpose of the report is to give other states with operating or planned decentralized I/M programs an opportunity to consider Colorado's innovative and highly successful method of data collection and analysis. The report describes the development and implementation of the Colorado system which uses machine readable forms in order to deal with the large amount of data generated from the many private garage inspection stations. The report also discusses a unique approach used by the State to ensure the use of the greatest amount of valid data in various categories of analysis. Appendices to the report contain complete documentation of the forms, procedures, and data analysis techniques used in the Colorado system.

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1.0 INTRODUCTION

1.1 Data Handling

This document will describe the inspection/maintenance (I/M) data handling system for the Automobile Inspection and Readjustment (AIR) Program operated by the State of Colorado. Machine readable forms (also called optically read or scanned forms) play a key role in that program's inspection data system. The intended purpose of this report is to provide detailed descriptive information for the consideration of other I/M programs. No data handling system should or can be exactly duplicated in another program. However, understanding the developmental process of one state's system does provide opportunities for other programs to select and refine those components which suit their unique needs.

Data handling is a crucial component of an inspection/maintenance program. It provides a "window" into that enigmatic system of stringency factors, types of repairs, calibrations, tailpipe inspections, reductions, costs, consumer protection, and quality control. The accuracy and completeness of data and the design and number of the analyses determine the validity and scope of the answer to the question, "How well is the I/M program operating?"

Data handling systems are designed through a series of compromises. Ideally, every element of applicable data would be collected, and each would be 100% accurate. The analyses would require only these data and, coping with all contingencies, they would accurately answer every question for the many constituents of the I/M program. If this ideal system were even achievable, the cost would be prohibitive. At a more realistic level, compromises are struck:

- completeness of data vs. costs of collection,
- completeness of data vs. accuracy of data,
- accuracy of data vs. costs to handle data,
- completeness and accuracy of data vs. ease of use,
- types of analyses vs. time requirements,
- types of analyses vs. costs of analyses, and
- types of analyses vs. value of information in analyses.

The result should be a data handling system which collects essential information with a moderate amount of cost and effort, which has a determinable measure of accuracy at or above an accepted standard, and which analyzes the data accurately and usefully. Each data handling system develops out of the needs of the I/M program it serves, balancing the ideal against the practical. Describing the data handling system developed by Colorado reports the efforts of one state to design a means of measuring the efficiency and quality of its I/M program.

1.2 Program Description

Senate Bill 52 (S.B. 52) established the Colorado Automobile Inspection and Readjustment (AIR) program. The bill outlines an annual, decenteralized inspection and adjustment program. Included in the program are all 1968 and newer model passenger cars and light-duty trucks in the following categories: 1968 through 1978 model years with a gross vehicle weight rating (GVWR) of 6,000 pounds or less, and 1979 and newer model years with a GVWR of 8,500 pounds or less. All diesel and propane powered vehicles, as well as motorcycles, are exempt. The program area originally involved a nine county area along the Colorado front range, from Colorado Springs in the south to Fort Collins in the north. One county was later excluded, leaving the program area the entire counties of Boulder, Denver, Douglas and Jefferson and urban areas of Adams, Arapahoe, El Paso, and Larimer counties.

Vehicles passing the idle test are issued a window sticker marked "pass." Five mandatory adjustments to manufacturers' specifications are made on vehicles for which emissions exceed state cutpoints, then a retest is conducted. Only on 1981 and newer vehicles are repairs mandated ($100 maximum) and this not until July 1, 1982. Vehicles which comply with the program requirements but are still not able to pass the state cutpoints are issued a window sticker marked "adjust." Inspections and adjustments are conducted at over 1,000 licensed private garages by more than 3,000 licensed mechanics. Adjustment by the vehicle owner is also allowed. The window sticker marked "adjust" cannot be issued unless the adjustments are done by a licensed emissions mechanic. The maximum failure rates allowed by statute (S.B. 52) are 40% for 1968-1974 model year vehicles and 30% for 1975 and newer model year vehicles.

The AIR Program is regulated by the Air Quality Control Commission, an interdisciplinary committee appointed by the legislature. Two state agencies, the Department of Health (CDH) and the Department of Revenue (CDR), share in the operational aspects of the program.

The Department of Health, Air Pollution Control Division, Mobile Sources Section is the agency responsible for technical aspects of the AIR Program. It operates three Vehicle Emissions Technical Centers at which specialized tests can be conducted. It coordinates all data handling; conducts public awareness activities; makes recommendations for emissions standards; handles the mechanic training and qualification program; and maintains contact with the mechanics in all matters related to S.B. 52 and technical aspects of the AIR Program. The Mobile Sources Section functions as a technical staff to the Air Quality Control Commission. The Department of Revenue, Motor Vehicle Division is concerned primarily with mechanic and station licensing (issue, deny, cancel, suspend, revoke) and enforcement. Splitting operational responsibilities between two agencies calls for special data handling efforts to ensure that each agency, as well as the Commission, receives the information it requires.

The development of Colorado's AIR program has had three distinct phases to date. A limited voluntary inspection program (phase one) had been operating since 1974, from which emissions data on about 20,000 vehicles had been gathered. The first mandatory inspections and adjustments (phase two) began July 1, 1981, for government fleets, new cars, vehicles changing ownership, and vehicles registering for the first time in the program area (new residents). This phase was expected to encompass about 80,000 vehicles over its six month span. In actuality, closer to 140,000 vehicles were inspected. The inspection form for the phase was printed with blue ink, thus providing a convenient designation for the data collecting and handling: the "blue system." With only 10% of the anticipated volume for the annual, expanded program, this July-December period functioned as a "pilot test" for the full-volume program. It allowed program staff opportunities to test procedures, cutpoints, and data analysis programs. Implementation of the full scale program began January 1, 1982, for an estimated 1.4 million vehicles in the program area.

This constitutes phase three, also called the "green system" after the green inspection form. The use of phases - the change of ownership and fleet I/M program (phase two) and the full volume program (phase three) - was a designed element intended to ease program implementation. The changes instituted for the "green system" frequently resulted from problems and solutions identified during the "blue system."

2.0 PRE-IMPLEMENTATION PLANNING

2.1 Sources of Planning Information

Sources of information used as input for pre-implementation planning included:

- data obtained in the seven-year old voluntary inspection program,
- data accrued during several contracted studies completed for the State of Colorado over approximately ten years,
- the data needs experienced by other I/M programs, and
- the data needs of this program as outlined in S.B. 52 and the State Implementation Plan (SIP).

2.2 Identifying Data Needs

In 1980 the Colorado Department of Health (CDH) sought assistance in evaluating the Air Division's entire data system. Arthur Young & Company of Dallas, Texas, was contracted to undertake the study. The project was completed in about eight months at an entire project cost of approximately $130,000. Included in the study was a section on I/M data needs, identifying the data requirements of the AIR Program. This section was subcontracted to Radian Corporation because of Radian's experience with I/M programs. Sections of the report dealing with the AIR Program appear in Appendix A of this document. The following raw data for the phases of the AIR Program emerged and are outlined in Table 1. The "Estimated" column states rough estimates of the total number of data elements which were expected to be processed annually for the "green system." The "Projected from Actual" column includes later figures calculated from actual inspection volumes. These latter figures are sketchy. Knowing actual data element quantities has not been essential to program management and the figures have not been officially tallied.

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Table 1: ESTIMATIONS OF DATA VOLUMES

Type	DATA VOLUMES (in millions)		
	Estimated[a] for Green	Projected from Actual	
		Blue[b]	Green
Vehicle Identification			
• License number	1.5	.14	1.4
Vehicle Characteristics			
• Model year		.14	1.4
• Make	1.5	.14	1.4
• No. of cylinders	1.5	.14	1.4
Administrative			
• Date of test	1.5	.14	1.4
• Inspection station number	1.5	.14	1.4
• Inspection station number - for adjustment only	0.1 (6.7%)	.024 (17%)	0.29 (21%)[c]
• Mechanic number	1.5	.14	1.4
• Mechanic number - for adjustment only	0.1	.024	0.29
• Certificate issued	1.5	.14	1.4
Cost			
• Inspection cost	1.5	.14	1.4
• Adjustment cost	0.5	.024	0.29
• Repair (labor) cost	0.1	d	e
• Repair (parts) cost	0.1	d	e
• Repair cost (total)	e	e	d,f
Inspection			
Initial Test Visual Inspection (subcategory)			
• Presence of catalytic converter	1.5	.14[g]	h
• Presence of fuel filler neck restrictor	1.5	.14	h
• Presence of AIR system	1.5	.14	h
• Integrity of exhaust systems	1.5	.14	h
Initial Test Emissions (subcategory)			
• CO percentage	1.5	.14	1.4
• CO pass/fail	1.5	.14	1.4
• HC parts per million	1.5	.14	1.4
• HC pass/fail	1.5	.14	1.4
Retest Visual (subcategory)			
• Presence of catalytic converter	0.5	g	h
• Presence of fuel filler neck restrictor	0.5	g	h
• Presence of AIR system	0.5	g	h
• Integrity of exhaust system	0.5	g	h
Retest Emissions (subcategory)			
• CO percentage	0.5	.024	0.29
• CO pass/fail	0.5	.024	0.29
• HC parts per million	0.5	.024	0.29
• HC pass/fail	0.5	.024	0.29

Table 1: ESTIMATIONS OF DATA VOLUMES

Type	DATA VOLUMES (in millions)		
		Projected from Actual	
	Estimated[a] for Green	Blue[b]	Green
Repair			
Voluntary Repair			
• Tune-up	0.1	i	e
• Carburetor	0.1	i	e
• Air cleaner	0.1	i	e
• Choke	0.1	i	e
• Other	0.1	i	e
Home adjust (subcategory)	0.1	i	e
• CO percent	0.1	i	e
• CO pass/fail	0.1	e	e
• HC PPM	0.1	i	e
• HC pass/fail	0.1	e	e
• Overall CO and HC pass/fail		i	e

[a] Arthur Young & Company, Colorado Air Pollution Control Division Information System [draft for review and correction by sponsor], (n.p.: n.p., 7 August 1981), Section 2.5.8, pp. 9-11.

[b] "Blue system" was six months; "green system" is annual beginning January 1982.

[c] Actual stringency is 17% as of 4/1/82. The standards will become more stringent and increase the failure rate to roughly 25%. 21% average for the year is used here.

[d] Repairs labeled "required" on blue form but were actually only voluntary. Repair is for 1981 and newer models and will not be mandatory until July 1, 1982.

[e] Data type not collected or estimated.

[f] This figure will be a small percentage of the 1981 and newer vehicle population as the number of inspected 1981 and newer vehicles increases. These vehicles are those which still fail after adjustment.

[g] A visual inspection was conducted for all vehicles under the "blue system." Failure data has not been analyzed.

[h] Under the "green system" the visual inspection is for 1982 and newer models. Because new vehicles are automatically passed without an inspection when new, 1982 models will not be inspected until 1983. First inspection figures will be 0% for 1982, growing to an estimated 50% of the volume of inspections by 1987. Economic factors could skew the projections that 50% of the vehicle population in 1987 will be 1982 or newer. A failure rate is difficult to estimate and is a measure of the amount of tampering occurring.

[i] No projections available.

The discrepancies between the estimated volumes and the volumes projected from actual inspection data are significant. This does not deny the value of pre-implementation study, or even a study completed by an outside contractor. It does suggest that figures generated early in planning stages should be used only as indicators of magnitude.

Identifying data needs for the AIR Program has been handled primarily by CDH Air Pollution Control Division staff members. They are familiar with the history of I/M in the state and thoroughly acquainted with procedural and administrative aspects of this program and I/M in general. The primary responsibility of one member, Kenneth Nelson, is data handling. His background includes data processing as it pertains to air pollution, and this familiarity with data processing concepts is beneficial when working with CDH Data Services staff members. It is this latter section, headed by Robert Little and under the immediate supervision of Richard Fawcett, which handles actual computer programming and systems design.

Identifying data needs is a constant process of reassessment. As legislation and regulation altered the program design, the identified data needs would require re-evaluation to be sure that type or volume was not affected. At each juncture a decision also needed to be made about the value of the information gathered and the effort required to obtain it. Did one outweigh the other? Should a compromise be struck? Identifying data needs continues, even when the program is operational, albeit to lesser degrees. To be efficient, only essential data should be gathered, but a constant redefinition of "essential" shows an awareness of the kaleidoscopic aspect of operational I/M programs.

2.3 Sampling

The anticipated volume of inspection data prompted Colorado to consider using data sampling techniques rather than the entire volume of data. Sampling is expected to produce less precise results than full volume analysis, but by greatly reducing the amount of data handled, costs are also reduced. The risks of sampling include possible bias in the collected data, thereby producing inaccurate results, and insufficient cost savings to balance the expected decrease in accuracy. Dr. Elmer Remmenga, professor of Statistics, Colorado State Univesity, proposed a 25% sample size of a 1.4 million records base. Even at that, the sample would still encompass about 350,000 inspection reports annually. In Dr. Remmenga's October 9, 1980 report to the Department of Health he suggests:

> With equal sample sizes, it would be very easy to obtain the probability that each station is out of compliance each sampled month for percent failed and change in HC and CO.
>
> Optical scanner records leading to an overall 80-90 percent sample would be preferable for efficiency, economics, and statistics.[1]

2.4 Data Collecting and Handling Alternatives

In Dr. Remmenga's estimation, a semi-automated data collection process using the entire database and with a 80-90% accuracy level was preferable to using sampling techniques. Additional research pointed out that using a semi-automated system and all the data records was not outrageously more expensive than a semi-automated system accessing only a sample of the collected data. Perhaps more importantly, the accuracy of the analyses using all the data would be greater than if only a sample of the data were used. Using machine readable forms, hand-coded by the inspecting mechanic, appeared to be a viable option in the progression of data collection and handling alternatives (Table 2).

---

[1] Elmer Remmenga, unpublished report to Colorado Department of Health, "Sample Size and Sample Plan Considerations for Evaluating Emission Test Records for Consumer Protection," 9 October 1980, p. 2. The report appears in its entirety in Appendix B of this document.

The following five alternatives were considered by the CDH staff:

Table 2: DATA COLLECTING AND HANDLING ALTERNATIVES

		COLLECTING		HANDLING	
		At Stations	From Stations	Submission	Analyses
Manual	1.	handwritten	by AIR staff	manually tabulated	manual
	2.	handwritten	by AIR staff	keypunched	computer
	3.	hand coded	by AIR staff	machine read	computer
	4.	data tape in analyzer and manually keyed data	by AIR staff	computer	computer
Automated	5.	data tape in analyzer and manually keyed data	data transfer over phone lines	computer	computer

1. A totally manual system was out of the question considering the data volume. The necessity for computer analysis was obvious. The primary problem was how to submit the data to the computer.

2. Keypunching was a possibility, but suffered from inherent problems. CDH estimates in August 1980 for data entry costs totaled $87,500 for 1.4 million inspections. Quality control of the data would demand that each inspection be keypunched twice, producing between two and three million records annually. Because the keypunchers would be reading handwritten copy, there appeared to be additional room for error beyond that intrinsic to keypunching.

3. Using a machine readable form would eliminate keypunching. The design of the form stipulates limits on the values which can be coded. A higher rate of accuracy is thereby promoted. The forms are traceable to the inspection station and mechanic, even manually, if need be. No special equipment is required by the inspection stations. The concept was already familiar to the CDH staff because machine readable forms had been used for several years in the Colorado Mechanics' Training Program to record answers for the certification test and to gather demographic information (see sections 2.5 and 3.2 of this document).

4. Purchasing special data collecting analyzers was considered but would have placed undue economic burden on the inspection stations. Although the automatically collected data would be accurate, there would be a risk of the manually keyed, vehicle specific data being inaccurate. Tracing or even identifying the inaccuracies would be extremely difficult. These units typically are self diagnostic, an advantage over analyzers which do not collect data. Additionally, the reviewing legislative body felt uncertain that the automated analyzers ultimately would be available at the costs and conditions stated by the interested manufacturers.

5. This system would be similar to that outlined under alternative four, except the data tapes would not need to be manually collected. The problems would be similar, but could be compounded by the application of data transmission to a decentralized program.

Two other systems were proposed as combinations of type three and four alternatives. One system attached to a standard analyzer, converted the analog data to digital, and transmitted it to a computer. A major concern centered around whether this "black box" would be compatible with the variety of analyzers in use. The other system was simply a keyboard on which all the data would be typed and thereby transmitted to a computer. The typing seemed to represent one more step removed from the actual data and could introduce an unusual amount of error. Rather than attempt a hybrid system, the AIR program elected to use machine readable forms.

2.5 Additional Investigations

Before the decision could be made to use machine read forms, the topic needed further investigation. Optical scanning equipment can be either Optical Character Readers (OCR), which decipher characters on a page, or Optical Mark Readers (OMR), which simply detect the absence or presence of marks, but not their shapes.

The CDH Data Services Section, being better aware of the entire scope of data needs for the Air Polution Control Division, had explored the feasibility of optical character recognition (OCR) equipment. Such a system actually ascertains which character is present in a field rather than simply sensing whether a mark is present. OCR is very versatile and could be used by other programs within the Health Department. The writer is not limited to just a Number 2 pencil; colored pen or pencil can be used. The equipment appeared to be more reliable than mark sensors, and text could even be input into word processing equipment elsewhere in the Department of Health. The primary problem with the AIR Program application lay in the OCR's speed: at a read rate of 225 inspection forms per hour, it could not handle the expected volume of data. Frequent operator intervention was also required. Equipment costs can begin at $65,000 for this type of OCR system. Another optical reader system which Colorado considered read hand printed numerals. Unfortunately, alphabetic characters were not as easily read, and Colorado vehicle licenses include both alphabetic and numeric characters. Other drawbacks of using this system included a high purchase price, a mechanics' training component which would be needed to teach mechanics how to correctly write the digits, and problems associated with the system's uniqueness: a back-up system would not be available, and timely service could be unavailable. After investigating the potential of this system, CDH concluded it would not be feasible for reasons of reliability and cost.

The Colorado Emissions Mechanic Training Program provided a significant opportunity to investigate a mark sensing system. Since 1977 Colorado State University, the contractor for the training program, has been using a machine readable form to record demographic information about the mechanics as well as the mechanics' answers for the certification test. The forms underwent several design changes the first several years. Because the forms are computer generated and printed on campus, redesigning the form is not difficult. The form can be printed on a variety of papers with dimensions from about 3" x 5" to 8½" x 11" or slightly larger. Red pre-printed text is in an 80 character by 60 line area on an 8½" x 11" page. The typeface is a standard ten character per inch, six lines per vertical inch, all upper case, numbers and selected symbols. An IBM 3881 Optical Mark

Reader scans the forms for circles blackened with a Number 2 pencil in selected areas of the form. It converts that data from printed form to numbers recorded on a 7-track tape. The taped data can undergo whatever computer analysis is necessary. The IBM 3881 can read an average of 3,000 forms per hour, depending on the type of form. Because mechanics complete this form when they take the qualification test for AIR Program licensing, they are already familiar with the concept of machine readable forms.

AIR Program staff was also familiar with Illinois' decentralized truck safety data collection system. It has used machine readable forms since 1975. In telephone discussions, an Illinois staff member related that their program initially had a roughly 50% completion rate, but that the rate had risen to a consistent 85% base rate on the initial reading. Some errors are correctable, so that fewer than 1,000 forms out of each batch are unusable. The Illinois program processes 10,000 forms in each batch using an IBM 3881 optical mark reader. More than 90% of the safety testers underwent training in regional workshops. The Illinois program seems to be the only other program in the United States using machine readable forms in a garage environment.

A data collection and handling system relying on coded forms and a mark sensor seemed increasingly feasible for the Colorado AIR Program. The ultimate decision would depend on two points:

- the cost of the data system, and
- the availability and type of equipment in Colorado.

These two points were investigated by the CDH Data Services Section for the AIR Program.

A decentralized system was one possibility: several relatively simple scanners distributed throughout the program area would read inspection forms at decentralized collection sites. The data could be transmitted over telephone lines to a centrally located computer for analysis. The Scan-tron model scanner which was proposed costs approximately $2,000 per unit. Unfortunately there was insufficient time to investigate thoroughly the reliability of that equipment. Were the AIR Program state-wide there also would be greater incentive for a decentralized data collection system; the current program area is within one and a half hour's driving time of Denver and currently does not justify a more elaborate, and perhaps less reliable, communications network. A centralized scanner system was decided upon.

Should CDH buy time on mark sensing equipment, or should it purchase the equipment? Although there probably are enough applications within the Department to support the equipment, the decision was made to buy services. The bids for services varied widely, but the successful bidder proposed a package that was more cost effective than purchasing the equipment. The compromise which offsets the lower costs is the decreased availability of the equipment for programming changes. Delays in changing source codes, for example, are to be expected simply because the equipment is not conveniently on site.

Availability was the determining factor in deciding which equipment to use. Data Services staff discovered that several sites were available in the Denver area, and that most of them were public school systems. Additionally, almost all of them used National Computer Systems, Inc. (NCS) equipment, perhaps because of NCS' marketing thrust. The NCS systems could cope with the types and volumes of AIR

Program data, so the remaining point was cost. Denver Public Schools (DPS), at 3800 York, approximately three miles from CDH offices, entered into an agreement with CDH. Because DPS is also a governmental agency, it could offer scanning services at $20 per hour, chargeable by the minute. Its equipment is a NCS Sentry 7010 with limited computer capability and a maximum read rate of 3,000 forms per hour. Practically speaking, 2,000 forms per hour is a typical functional rate. A system of this type can cost more than $85,000. A formal letter of agreement, renewable annually, was made with DPS for the use of their equipment, and that agreement has undergone minor modifications since it first went into effect. The relationship between the AIR Program and DPS seems cordial enough that minor problems in the system can be handled without formal negotiations. Items to be considered in a formal agreement with a contractor include:

- How many forms will be read in a given time period (e.g. 20,000 forms per week)?
- Will the contractor make arrangements to have forms read elsewhere if his equipment goes down? Who pays the third party?
- Will the contractor guarantee use of the existing equipment over several years or a recourse if the contractor changes equipment?
- What schedules will be kept by both parties?
- What accessibility for programming will be allowed?
- Can other services be provided (orienting forms, storage, etc.)?
- What will the costs be and what are the payment schedules?

The Colorado AIR Program chose optical mark sensing equipment because neither a less automated nor a more automated system seemed feasible. Less automated systems could not cope with the data volumes; more automated systems - specifically data collecting analyzers - put undue financial burdens on the inspection stations and could prove less reliable than predicted. Other types of optical scanning equipment were rejected because of high costs, lack of availability, slow speeds, or poor reliability. Additionally, optical mark sensing equipment was available at several sites and at reasonable rates. A formal agreement with the contractor ended the hunt for adequate equipment and moved the AIR Program data system into implementation.

3.0 IMPLEMENTATION OF DATA SYSTEM

3.1 Inspection Form

The inspection form is a crucial element of the data collection process. The form currently in use by the Colorado AIR Program is the product of months of development by AIR Program staff. Numerous designs evolved over this period. Although some of the design changes were necessitated by program modifications, most were initiated by the AIR Program staff to clarify and simplify the form, making it more efficient and insuring that it collected essential data. The developmental process might have been shortened if the AIR Program staff had been able to consult forms design experts much earlier. As it was, the National Computer Systems, Inc. (NCS) class on forms design could not be scheduled until June 1981, six months after forms design work was begun. An NCS instructor taught the five day course in Denver for the AIR Program at a cost of $2,200.

A concern of the program was to provide the motorist with a copy of pertinent data for the inspected car. If the vehicle failed the inspection, the owner could choose to have the vehicle adjusted other than at the original inspection station and would need the inspection information for a free re-test at the original station. A tear-off part of the inspection form, kept in the glove compartment of the car, was originally planned. The inspection procedure therefore required entering selected data on both the top section and the bottom, tear-off section of the form. Later, the motorist's form was converted from a tear-off section of the first page to the entire third page of a three page carbon form. Still, designing the front page so that it was compatible with the last (third) page presented many complications.

Preceding page blank

Changes initiated over the development of the form include:

- coding the inspection stations' and mechanics' numbers rather than writing them in by hand
- avoiding double entries
- decreasing the amount of information to be coded
    - collecting only total repair costs, not broken down by labor and parts
    - collecting rounded dollar amounts instead of dollars and cents
    - collecting number of cylinders, not cylinders and displacement
- numbering the data blocks to help guide the mechanic in using the form
- adding, then deleting areas where validation punches could be used
- printing more explicit instructions on the form, and
- moving data blocks on the form
    - for more prominence, and
    - to follow the flow of procedures more closely rather than grouping types of data.

The NCS scanner assumes alphabetic characters begin columns; a program was written to restructure the license data, but the AIR staff now knows the alphabetic characters in each column should precede the numeric characters. This is an example of equipment-specific requirements which impact other aspects of the data system.

Based on the data required, the size of the form has become 8½" x 12", with a 5/8" strip at the top to hold the three pages and two carbon sheets together. The design of the form is a decision to which both the Department of Revenue (CDR) and the Department of Health (CDH) contribute. CDH handles the technical design considerations with NCS, but the ordering and handling of the forms is a responsibility of CDR. The printing costs vary from $.074 to $.096 per form, depending on the quantity ordered. Additional mock-up costs are applicable (Appendix F). They are ordered in quantities of 750,000 now that the program is operating at full volume. Five weeks time from order to delivery is typical. The forms are printed in color (July 1981 - December 1981 in blue; January 1982 and later in green) to aid distinction between the two forms. NCS prints the forms on its own "Trans-Optic"® bond paper, which is guaranteed readable; other firms have informed the AIR Program that they can print the forms at a lower cost, but no decision has been made regarding changing from NCS printed forms. In Figure 1 are printed, in reduced format, the "blue form" used from July to December, 1981 and the "green form" currently in use. The instructions appear on the reverse of the third page of each inspection form. As an example of the types of changes which have occurred or which are scheduled to occur, contrast the two forms in Figure 1 (full sized photographs of the forms appear in Appendix D). Because of a contemplated change in the standards, the next revision of the inspection form will eliminate the printed block with the state standards, thus avoiding the obsolete form problem. The two empty blocks on the green form have been reserved for the two-speed idle test data to be gathered beginning in July 1982 for 1981 and newer vehicles. A copy of this newest form also appears in Appendix D.

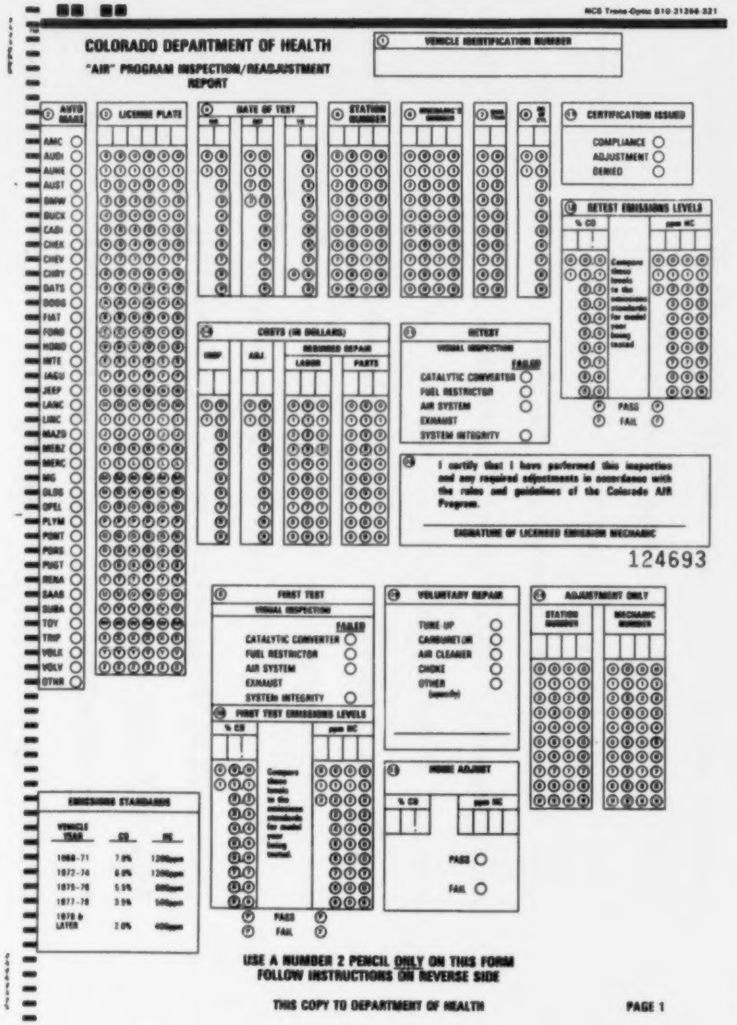
Although a complete redesign of the computer data capture program took place with the change from the blue forms to the green, it was necessitated by other factors (sections 4.1 and 4.2) than the form revision alone. Even small changes on the form can require major reprogramming because of the interrelations of data, data manipulation, and equipment requirements.

Compromises on the form include some hand-written information (collected as a last recourse for manual vehicle matching) and financial data collected only to the dollar. The newest form asks the mechanic to enter the actual cost, including cents, then code only the dollar amount. This discourages rounding the dollar amounts. Compensation factors are included in financial calculations where appropriate.

Figure 1: FORMS CONTRAST

FIRST PAGE

Blue System
July - December 1981



NCS Trans-Optic 010-31396-321

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE

AMC ○ AUDI ○ AUHE ○ AUST ○ BMW ○ BUCK ○ CADI ○ CHEK ○ CHEV ○ CHRY ○ DATS ○ DODG ○ FIAT ○ FORD ○ HOND ○ INTE ○ JAGU ○ JEEP ○ LANC ○ LINC ○ MAZD ○ MEBZ ○ MERC ○ MG ○ OLDS ○ OPEL ○ PLYM ○ PONT ○ PORS ○ PUGT ○ RENA ○ SAAB ○ SUBA ○ TOY ○ TRIP ○ VOLK ○ VOLV ○ OTHR ○

③ LICENSE PLATE

④ DATE OF TEST

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑬ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

RETEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested.

PASS
FAIL

COSTS (IN DOLLARS)

INSP | ADJ | REQUIRED REPAIR: LABOR | PARTS

RETEST

VISUAL INSPECTION

FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

FIRST TEST

VISUAL INSPECTION

FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

FIRST TEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested.

PASS
FAIL

VOLUNTARY REPAIR

TUNE UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER (specify) ○

IDLE ADJUST

% CO | ppm HC

PASS ○
FAIL ○

ADJUSTMENT ONLY

STATION NUMBER | MECHANIC NUMBER

EMISSIONS STANDARDS

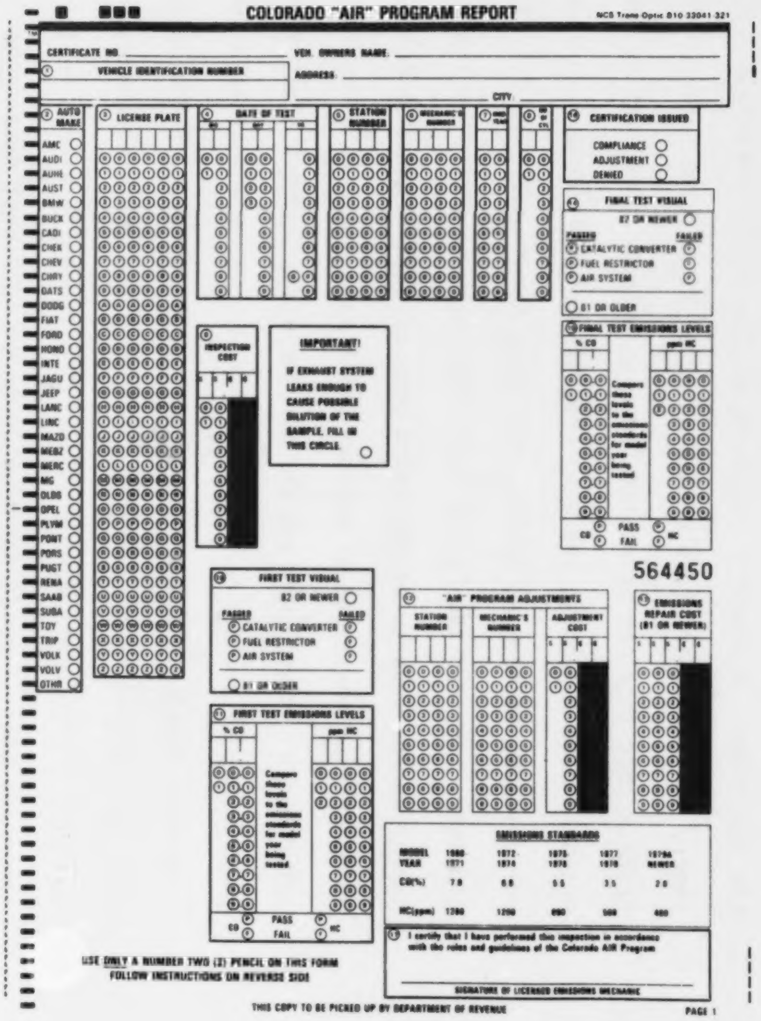
VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

USE A NUMBER 2 PENCIL ONLY ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO DEPARTMENT OF HEALTH

PAGE 1

Green System
January 1982 - Current



COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic 010-33041-321

CERTIFICATE NO. ______
VEH. OWNERS NAME: ______
ADDRESS: ______
CITY: ______

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE

AMC ○ AUDI ○ AUHE ○ AUST ○ BMW ○ BUCK ○ CADI ○ CHEK ○ CHEV ○ CHRY ○ DATS ○ DODG ○ FIAT ○ FORD ○ HOND ○ INTE ○ JAGU ○ JEEP ○ LANC ○ LINC ○ MAZD ○ MEBZ ○ MERC ○ MG ○ OLDS ○ OPEL ○ PLYM ○ PONT ○ PORS ○ PUGT ○ RENA ○ SAAB ○ SUBA ○ TOY ○ TRIP ○ VOLK ○ VOLV ○ OTHR ○

③ LICENSE PLATE

④ DATE OF TEST

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MODEL YEAR

⑧ NO. OF CYL.

⑭ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

FINAL TEST VISUAL

82 OR NEWER ○

PASSED | FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ

○ 81 OR OLDER

FINAL TEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO PASS HC
FAIL

⑨ INSPECTION COST

IMPORTANT!

IF EXHAUST SYSTEM LEAKS ENOUGH TO CAUSE POSSIBLE DILUTION OF THE SAMPLE, FILL IN THIS CIRCLE. ○

564450

FIRST TEST VISUAL

82 OR NEWER ○

PASSED | FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ

○ 81 OR OLDER

FIRST TEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO PASS HC
FAIL

"AIR" PROGRAM ADJUSTMENTS

STATION NUMBER | MECHANIC'S NUMBER | ADJUSTMENT COST

EMISSIONS REPAIR COST (81 OR NEWER)

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program

SIGNATURE OF LICENSED EMISSIONS MECHANIC

USE ONLY A NUMBER TWO (2) PENCIL ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO BE PICKED UP BY DEPARTMENT OF REVENUE

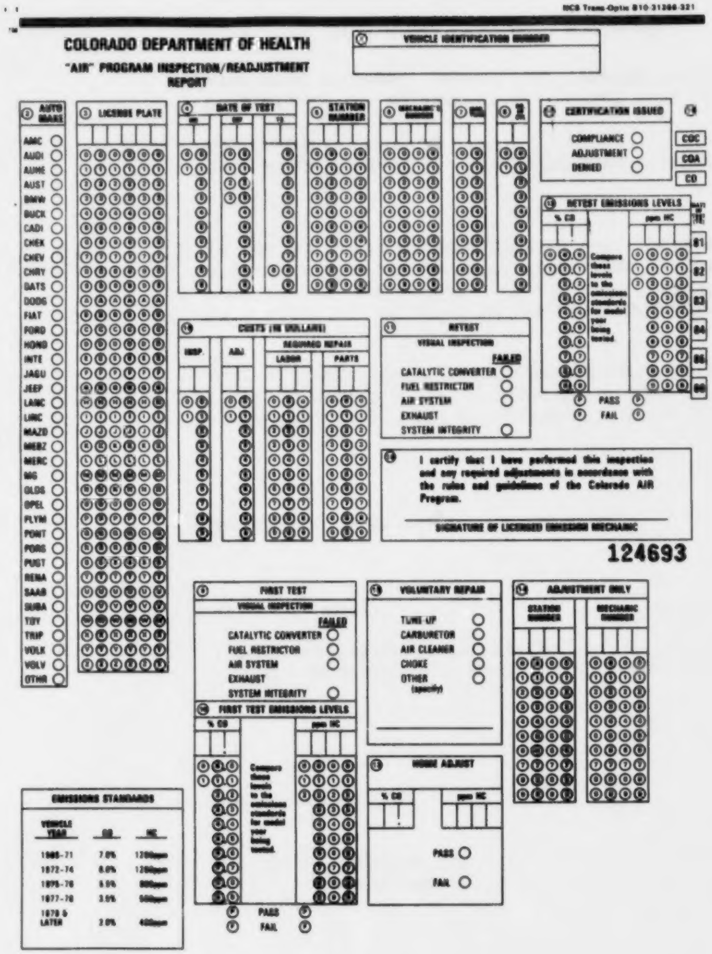
PAGE 1

FIRST PAGE

Blue System July - December 1981	**Green System** January 1982 - Current
Not collected.	Certificate (sticker) number written in allows matching of sticker, vehicle, and inspection form if necessary. Vehicle owner's name and address recorded for manual identification if necessary.
Title: Department of Health "AIR" Program Inspection/Readjustment Report.	Title: Colorado "AIR" Program Report.
Alternate coding columns shaded for ease of use.	All mandatory data blocks for the first inspection shaded to focus attention on them, and alternate coding columns shaded darker.
Data block 16 groups all dollar costs.	Data block 9 is inspection cost, grouped with other inspection activities, not other costs. Mechanic writes in dollars and cents, then codes only dollars.
Instruction say "Cost (in dollars)" and only dollar blocks are available. Rounded dollars could be given. Repair costs are collected for both parts and labor.	Adjustment costs appear in block 12 with other adjustment data. Repair costs (total only and requested specifically for 1981 and newer models) are in block 13.
Data block 9: attached to block 10, producing a complicated looking box. Circle coded only if status is "fail." On which models the visual inspection is to be conducted is not specified.	Exhaust system integrity section as separate block and more clearly labeled. More complete instructions, including mechanic identifying whether 81 or older/82 or newer vehicle. Pass and fail options available, not just fail, and labeled as P and F within coding circles.
Data block 10 and 12: HC and CO pass/fail circles not boxed.	Pass/fail circles included in data blocks and more clearly labeled.
Data blocks for adjustment and retest (11, 12, 14) scattered on page. Second test labeled "retest."	Adjustment data grouped (12, 13, 14, 15). Second test now called "final test."
Block 13: home adjustment data captured.	Block eliminated.
Emissions standards printed lower left. Signature block in middle of page.	Emissions standards printed lower right, over bottom right signature block. Space left on form for data blocks to be added as needed.
Instructions: "Use a number 2 pencil only on this form...This copy to Department of Health."	Instructions rewritten for accuracy: "Use only a number two (2) pencil on this form...This copy to be picked up by Department of Revenue."

SECOND PAGE

Blue System
July - December 1981



NCS Trans-Optic 810-31286-321

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE
AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MERZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑬ CERTIFICATION ISSUED
COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

CDC
CDA
CD

⑫ RETEST EMISSIONS LEVELS
% CO
ppm HC
Compare these levels to the emissions standards for model year being tested
81
82
83
84
85
86
PASS
FAIL

⑩ COSTS (IN DOLLARS)
INSP.
ADJ.
REQUIRED REPAIR
LABOR
PARTS

⑪ RETEST
VISUAL INSPECTION
FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

⑧ FIRST TEST
VISUAL INSPECTION
FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

FIRST TEST EMISSIONS LEVELS
% CO
ppm HC
Compare these levels to the emissions standards for model year being tested.
PASS
FAIL

VOLUNTARY REPAIR
TUNE-UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER (specify) ○

HOME ADJUST
% CO
ppm HC
PASS ○
FAIL ○

ADJUSTMENT ONLY
STATION NUMBER
MECHANIC NUMBER

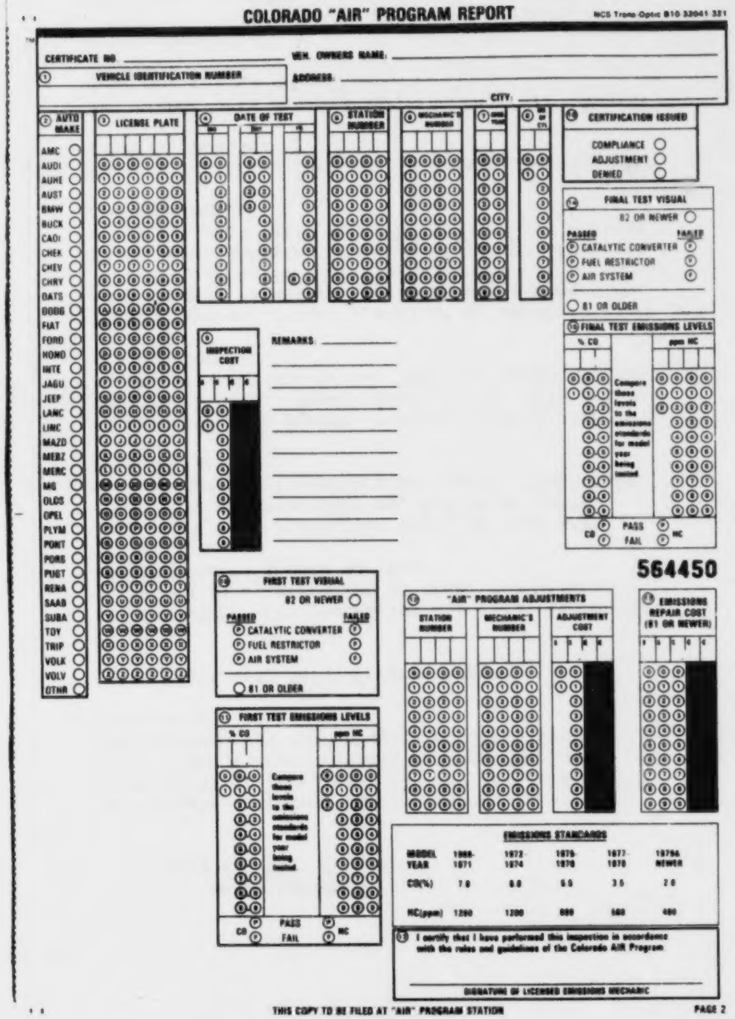
EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

THIS COPY TO BE FILED AT AIR PROGRAM STATION

PAGE 2

Green System
January 1982 - Current



COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic 810-33041-321

CERTIFICATE NO. ____________
VEH. OWNERS NAME: ____________
① VEHICLE IDENTIFICATION NUMBER
ADDRESS: ____________
CITY: ____________

② AUTO MAKE
AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MERZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑧ NO. OF CYL.

⑭ CERTIFICATION ISSUED
COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

FINAL TEST VISUAL
82 OR NEWER ○
PASSED
FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ
○ 81 OR OLDER

⑨ INSPECTION COST

REMARKS: ____________

⑯ FINAL TEST EMISSIONS LEVELS
% CO
ppm HC
Compare these levels to the emissions standards for model year being tested
CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

564450

FIRST TEST VISUAL
82 OR NEWER ○
PASSED
FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ
○ 81 OR OLDER

⑪ FIRST TEST EMISSIONS LEVELS
% CO
ppm HC
Compare these levels to the emissions standards for model year being tested.
CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

"AIR" PROGRAM ADJUSTMENTS
STATION NUMBER
MECHANIC'S NUMBER
ADJUSTMENT COST

EMISSIONS REPAIR COST (81 OR NEWER)

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program

SIGNATURE OF LICENSED EMISSIONS MECHANIC

THIS COPY TO BE FILED AT "AIR" PROGRAM STATION

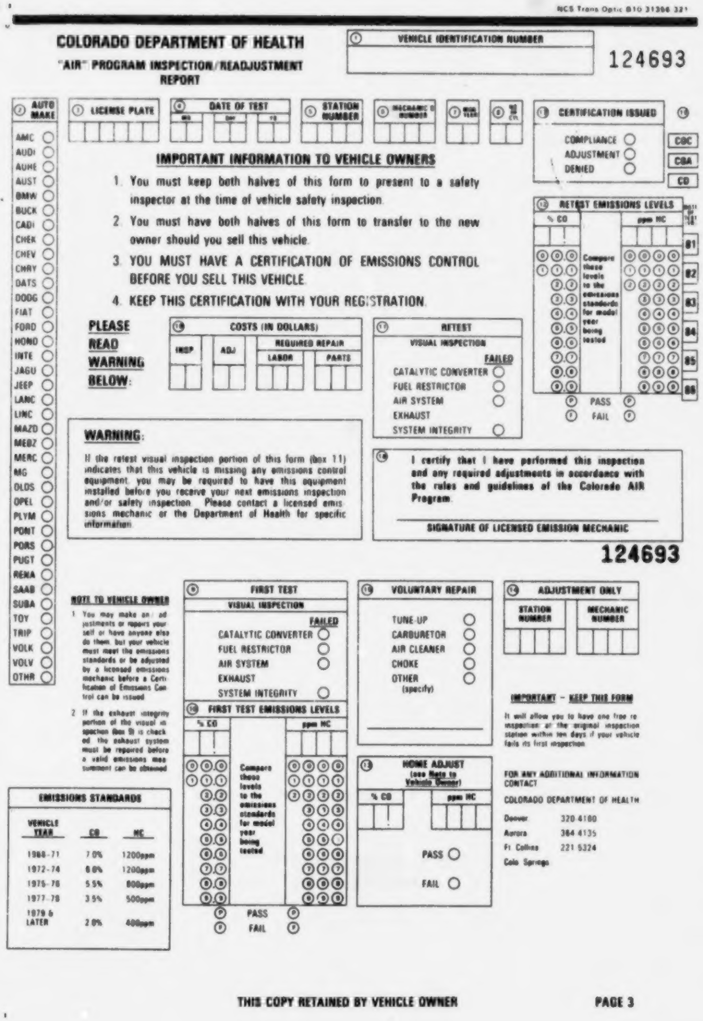
PAGE 2

SECOND PAGE

Blue System July - December 1981	**Green System** January 1982 - Current
Identical to page 1.	Identical except exhaust system block is converted to ten lines for remarks.

THIRD PAGE

Blue System
July - December 1981



NCS Trans-Optic 810 31394 321

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

124693

② AUTO MAKE
AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO / DAY / YR

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MOD. YEAR

⑧ NO. OF CYL.

⑬ CERTIFICATION ISSUED
COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑯ COC
CoA
CD

IMPORTANT INFORMATION TO VEHICLE OWNERS

1. You must keep both halves of this form to present to a safety inspector at the time of vehicle safety inspection.
2. You must have both halves of this form to transfer to the new owner should you sell this vehicle.
3. YOU MUST HAVE A CERTIFICATION OF EMISSIONS CONTROL BEFORE YOU SELL THIS VEHICLE.
4. KEEP THIS CERTIFICATION WITH YOUR REGISTRATION.

PLEASE READ WARNING BELOW:

⑩ COSTS (IN DOLLARS)

INSP	ADJ	REQUIRED REPAIR	
		LABOR	PARTS

⑪ RETEST
VISUAL INSPECTION
FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

⑫ RETEST EMISSIONS LEVELS
% CO — ppm HC
Compare these levels to the emissions standards for model year being tested
Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ
81
82
83
84
85
86

WARNING:

If the retest visual inspection portion of this form (box 11) indicates that this vehicle is missing any emissions control equipment, you may be required to have this equipment installed before you receive your next emissions inspection and/or safety inspection. Please contact a licensed emissions mechanic or the Department of Health for specific information.

⑭ I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

NOTE TO VEHICLE OWNER

1. You may make any adjustments or repairs yourself or have anyone else do them, but your vehicle must meet the emissions standards or be adjusted by a licensed emissions mechanic before a Certification of Emissions Control can be issued.
2. If the exhaust integrity portion of the visual inspection (box 9) is checked, the exhaust system must be repaired before a valid emissions measurement can be obtained.

EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

⑨ FIRST TEST
VISUAL INSPECTION
FAILED
CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

⑩ FIRST TEST EMISSIONS LEVELS
% CO — ppm HC
Compare these levels to the emissions standards for model year being tested
Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

⑪ VOLUNTARY REPAIR
TUNE-UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER ○
(specify)

⑫ HOME ADJUST
(see Note to Vehicle Owner)
% CO — ppm HC
PASS ○
FAIL ○

⑭ ADJUSTMENT ONLY
STATION NUMBER — MECHANIC NUMBER

IMPORTANT – KEEP THIS FORM

It will allow you to have one free re-inspection at the original inspection station within ten days if your vehicle fails its first inspection.

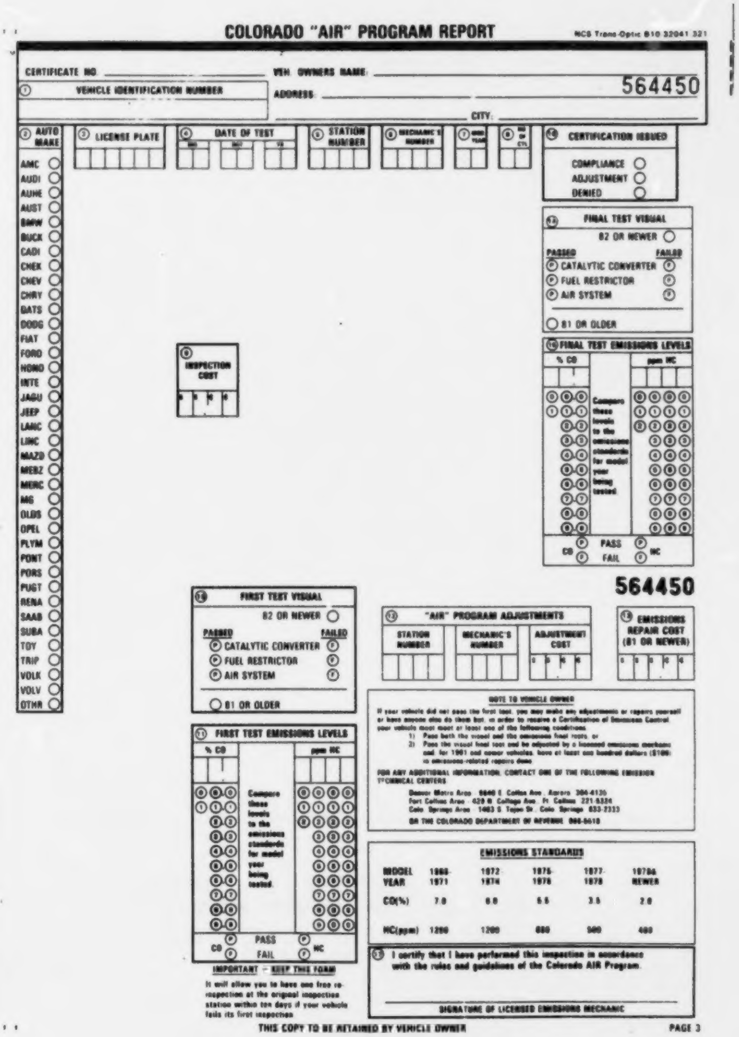
FOR ANY ADDITIONAL INFORMATION CONTACT
COLORADO DEPARTMENT OF HEALTH

Denver	320 4180
Aurora	364 4135
Ft. Collins	221 5324
Colo. Springs	

THIS COPY RETAINED BY VEHICLE OWNER

PAGE 3

Green System
January 1982 - Current



COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic 810 32041 321

CERTIFICATE NO. ____________ VEH. OWNERS NAME: ____________

ADDRESS: ____________

CITY: ____________

① VEHICLE IDENTIFICATION NUMBER

564450

② AUTO MAKE
AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO / DAY / YR

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MOD. YEAR

⑧ NO. OF CYL.

⑯ CERTIFICATION ISSUED
COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑨ INSPECTION COST

⑭ FINAL TEST VISUAL
82 OR NEWER ○
PASSED — FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ
○ 81 OR OLDER

⑮ FINAL TEST EMISSIONS LEVELS
% CO — ppm HC
Compare these levels to the emissions standards for model year being tested
CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

564450

⑩ FIRST TEST VISUAL
82 OR NEWER ○
PASSED — FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ
○ 81 OR OLDER

⑪ FIRST TEST EMISSIONS LEVELS
% CO — ppm HC
Compare these levels to the emissions standards for model year being tested.
CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

IMPORTANT – KEEP THIS FORM

It will allow you to have one free re-inspection at the original inspection station within ten days if your vehicle fails its first inspection.

⑫ "AIR" PROGRAM ADJUSTMENTS
STATION NUMBER — MECHANIC'S NUMBER — ADJUSTMENT COST

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

NOTE TO VEHICLE OWNER

If your vehicle did not pass the first test, you may make any adjustments or repairs yourself or have anyone else do them but, in order to receive a Certification of Emissions Control your vehicle must meet at least one of the following conditions:

1) Pass both the visual and the emissions final tests, or
2) Pass the visual final test and be adjusted by a licensed emissions mechanic and, for 1981 and newer vehicles, have at least one hundred dollars ($100) in emissions-related repairs done.

FOR ANY ADDITIONAL INFORMATION, CONTACT ONE OF THE FOLLOWING EMISSION TECHNICAL CENTERS:

Denver Metro Area: 9840 E. Colfax Ave., Aurora 364-4135
Fort Collins Area: 420 N. College Ave., Ft. Collins 221-6334
Colo. Springs Area: 1483 S. Tejon St., Colo. Springs 633-2333
OR THE COLORADO DEPARTMENT OF REVENUE 866-5610

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979 & NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSIONS MECHANIC

THIS COPY TO BE RETAINED BY VEHICLE OWNER

PAGE 3

THIRD PAGE

Blue System July - December 1981	**Green System** January 1982 - Current
Information for the vehicle owner appears in four sections on the form. CDH listed as source of further information, along with just phone numbers of Technical Centers.	Information for the vehicle owner consolidated into two blocks, both of which are in the lower right corner. CDR listed as source of further information, along with phone numbers and addresses of Technical Centers.
Block 19: punch blocks to verify authenticity of the inspections, at the right edge.	Punch blocks eliminated because the form is not a controlled document.

INSTRUCTIONS (REVERSE OF THIRD PAGE)

Blue System
July - December 1981

INSTRUCTIONS TO LICENSED EMISSIONS MECHANICS
(ONLY a Licensed Emissions Mechanic may perform this inspection.)

NOTICE

The first copy (top) of this form will be scanned electronically.

Please keep the top copy free of dirt or grease.

Do NOT fold, staple, spindle, or mutilate top copy.

Do NOT make ANY marks on the top copy other than specified in directions.

You may make notes on the second or third copies ONLY.

Use ONLY a NUMBER TWO pencil on this form.

Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC:

ENTER: % CO 0 4 8 ppm HC 0 7 5 0 DO NOT ENTER: % CO 4 8 0 ppm HC 7 5 0 0

Except for Item ① (Vehicle Identification Number), after the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be just one circle filled in under each box.

FIRST INSPECTION

A. Complete items ① through ⑧

B. Do the first test visual and emissions inspection ⑨ and ⑩, (mark PASS or FAIL for CO and HC).

C. If the vehicle passes both the visual and emissions inspection, mark "Compliance" ⑰, sign the form ⑱, punch COC ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

D. If the vehicle fails the visual or emissions inspection and the adjustments or repairs are done at your station, complete item ⑪ and go on to Step G.

If the vehicle owner wants the work done elsewhere, give him/her the bottom part of page 3 to be filled in by the person who does the work and returned within 10 days for a free reinspection.

REINSPECTION

E. If the vehicle was adjusted or repaired by a Licensed Emissions Mechanic, copy the station and mechanic's license numbers from the "Adjustment Verification" form under item ⑪, attach one copy of the "Adjustment Verification" form to page 2, and go on to Step G.

F. If the vehicle was adjusted or repaired by a non-licensed person, complete item ⑫. If the vehicle passes, go on to Step G. If it fails, make the adjustments or repairs required and go on to Step G or mark "Denied" ⑰, sign the form ⑱, punch CD ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

G. If the vehicle failed the first test visual, do the retest visual inspection ⑬, if it passed the first test visual, go on to step H.

H. Do the retest emissions inspection ⑭, (mark PASS or FAIL for CO and HC).

I. Record the amount charged for the inspection, the adjustments (if performed), and the labor and parts costs for required repairs ⑮.

J. Record any voluntary repairs ⑯.

K. If the vehicle passes both the visual and the emissions retests, mark "Compliance" ⑰, sign the form ⑱, punch COC ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

L. If the vehicle passes the visual retest but fails the emissions retest (and, for 1981's and newer, $100.00 was spent on emissions repairs) mark "Adjustment" ⑰, sign the form ⑱, punch COA ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

M. If the vehicle fails the visual retest (or, for 1981's and newer, fails the emissions retest and less than $100 was spent on emissions repairs) mark "Denied" ⑰, sign the form ⑱, punch CD ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

Green System
January 1982 - Current

INSTRUCTIONS TO LICENSED EMISSIONS MECHANICS
(ONLY a Licensed Emissions Mechanic may perform this inspection.)

NOTICE

- The first copy (top) of this form will be scanned electronically
- Please keep the top copy free of dirt or grease
- Do NOT fold, staple, spindle, or mutilate top copy
- Do NOT make ANY marks on the top copy other than specified in directions
- You may make notes on the second or third copies ONLY
- Use ONLY a NUMBER TWO pencil on this form
- Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC
- Except for Item ① (Vehicle Identification Number), after the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be just one circle filled in under each box

ENTER % CO 0 4 8 ppm HC 0 7 5 0 DO NOT ENTER % CO 4 8 0 ppm HC 7 5 0 0

FIRST INSPECTION

PRINT - Name and address of vehicle owner at top of this form

ITEM

① Vehicle Identification Number - Write in VIN number

② Auto Make - Fill in circle for auto make

③ License Plate - Enter license plate number and fill in circles (if temporary tag leave blank, if more than six characters use first six)

④ Date of Test - Enter month, day and year and fill in circles.

⑤ Station Number - Enter your station's license number and fill in circles.

⑥ Mechanic's Number - Enter your emissions mechanic's license number and fill in circles.

⑦ Model Year - Enter last two digits of vehicle's model year and fill in circles (example: 1972 enter 72).

⑧ No. of Cyl. - Enter number of cylinders in engine and fill in circles (if rotary engine enter number of rotors)

⑨ Inspection Cost - Enter cost of inspection in dollars and cents (maximum $10.00) and fill in circles under dollar portion only

⑩ First Test Visual - For 1981 and older vehicles, fill in "81 OR OLDER" circle (no visual inspection needed)

For 1982 and newer vehicles, fill in "82 OR NEWER" circle, complete first visual inspection and fill in a pass or fail circle for each emissions control system

⑪ First Test Emissions Levels - Complete first emissions inspection, enter readings and fill in circles. Compare readings to State standards and fill in pass or fail circles for CO and for HC.

NOTE: THIS COMPLETES FIRST INSPECTION. IF VEHICLE HAS PASSED ALL REQUIREMENTS, FILL IN "COMPLIANCE" CIRCLE IN ITEM ⑯ AND SIGN ITEM ⑰. ENTER CERTIFICATE OF EMISSIONS CONTROL NUMBER AT TOP OF FORM. GIVE THIRD COPY TO VEHICLE OWNER AND AFFIX CERTIFICATE OF EMISSIONS CONTROL STICKER TO THE WINDSHIELD AS SPECIFIED

VEHICLES FAILING FIRST INSPECTION

ITEM

⑫ "AIR" Program Adjustments - If adjustments were made by a licensed emissions mechanic, enter license numbers of station and mechanic where adjustments were made and cost of adjustments in dollars and cents (maximum $15.00). Fill in circles under station number, mechanic's number and dollar portion of adjustment cost. NOTE: If adjustments were made by another licensed emissions mechanic, copy this information from "Adjustment Verification Form".

⑬ Emissions Repair Cost - For 1981 and newer vehicles, enter cost of emissions related repairs in dollars and cents and fill in circles under dollar portion only.

⑭ Final Test Visual - For 1981 and older vehicles, fill in "81 OR OLDER" circle (no visual inspection needed).

For 1982 and newer vehicles, fill in "82 OR NEWER" circle, complete final visual inspection and fill in a pass or fail circle for each emissions control system.

⑮ Final Test Emissions Levels - Complete final emissions inspection, enter readings and fill in circles. NOTE: If adjustments were made by another licensed emissions mechanic, copy readings from "Adjustment Verification Form". Compare readings to State standards and fill in pass or fail circles for CO and for HC.

⑯ Certification Issued - Fill in circle next to

COMPLIANCE	if item ⑭ passed and item ⑮ is within State standards
ADJUSTMENT	if item ⑭ passed, item ⑮ failed, adjustments done by licensed mechanic and, for 1981 and newer vehicles, at least $100 spent on emissions related repairs
DENIED	if item ⑭ failed or item ⑮ failed and 1) adjustments not done by licensed mechanic or 2) for 1981 and newer vehicles, less than $100 spent on emissions repairs

⑰ Signature of Licensed Emissions Mechanic - After completing this form, sign it, enter number of the certificate issued (or "none" if certification denied) at top of form and give third copy to vehicle owner. If a certification is issued, affix certificate of emissions control sticker to the windshield as specified

INSTRUCTIONS (REVERSE OF THIRD PAGE)

Blue System	**Green System**
July - December 1981	January 1982 - Current
Instructions grouped by 1) form, 2) first inspection, and 3) re-inspection. Printed across the page, alphabetically labeled in steps.	Instructions organized by 1) form, 2) first inspection, and 3) vehicles failing first inspection. Boxed by topics. Instructions ordered by data block numbers for easier reference. Each block has instructions.

3.2 Mechanics' Training

Mechanics wishing to be licensed to conduct AIR inspections and adjustments must first be qualified. "Qualification" consists of passing a written test (25 technical questions, 25 rules and regulations questions) and a performance test. The mechanics may take the qualification tests free of charge by appointment at one of the three Vehicle Emissions Technical Centers (VETC) in the program area. However, the mechanics are encouraged to enroll in a 16-hour training course before attempting the tests. The cost of the course is $25.00, which covers the instructors' and facilities' fees and mailing. The course consists of four classes (usually Tuesday and Thursday, 6 p.m. to 10 p.m., two consecutive weeks) conducted by a trained instructor. The text book for the course has been developed under contract by the Colorado State University project staff over a span of several years, with revisions and additions being made as necessary. One unit of that training manual is devoted to completing the machine read inspection form. The unit appears in its entirety in Appendix C. A mock-up of an inspection form was included in the manual even before the first form was finalized or in use. That unit has been revised regularly. One hour of the third class and one hour of the fourth class include instructions on the use of the inspection form, and the performance test requires the mechanic to complete an actual inspection form. Seven questions in the 85-item computerized bank of rules and regulations questions relate to the inspection form. A mechanic not electing to take the emissions course may obtain a free training manual at a Vehicle Emissions Technical Center (VETC) but receives no additional instruction on the form. The machine read answer sheet on which the mechanic marks his responses to the written qualification test reinforces some of the basics of completing optically read forms:

- use a Number 2 pencil,
- mark only one circle in each row or column,
- fill each circle completely and neatly,
- complete all items, and
- do not fold or staple the form or get it wet or dirty.

It is difficult to isolate from the other training topics the costs of training mechanics to complete the inspection form. Because two of the sixteen hours of instruction are devoted to the form, one eighth of the $25.00 fee could be considered part of the costs ($3.13/mechanic). The training manual is printed under contract by Colorado State University at a cost of approximately $4.90 each. The unit on inspection forms comprises roughly 10% of that document, or $.50. The development of the unit has either been completed by the Colorado State University project staff under contract to the Department of Health or, in 1981-82, by the AIR Program staff. It entails about 80 man hours and an estimated $100.00 worth of black and white graphics taken from the actual inspection form. The initial development represents an investment of perhaps $1,500; minor revisions are considerably less. Twelve color slides pertaining to the inspection form were developed for the class instructors, at a cost of about $7.60/slide. Each slide consists of a photograph of an actual inspection form covered with a sheet of yellow transparent film over all except the data block being discussed. These slides are reproduced at Colorado State University at a cost of $.38 each in quantities of 25 or more.

As difficult as it is to isolate the expense of training mechanics to complete the inspection form, some identified costs include:

per mechanic:	$ 3.13	class
	.50	text
	$ 3.63	(does not include testing or record-keeping)
development:	$1,500	initial text development
	850	major revision to text
	91	(12 x $7.60) slide development
	140	(12 x $.38 x 30 sets) slide production
	$2,581	

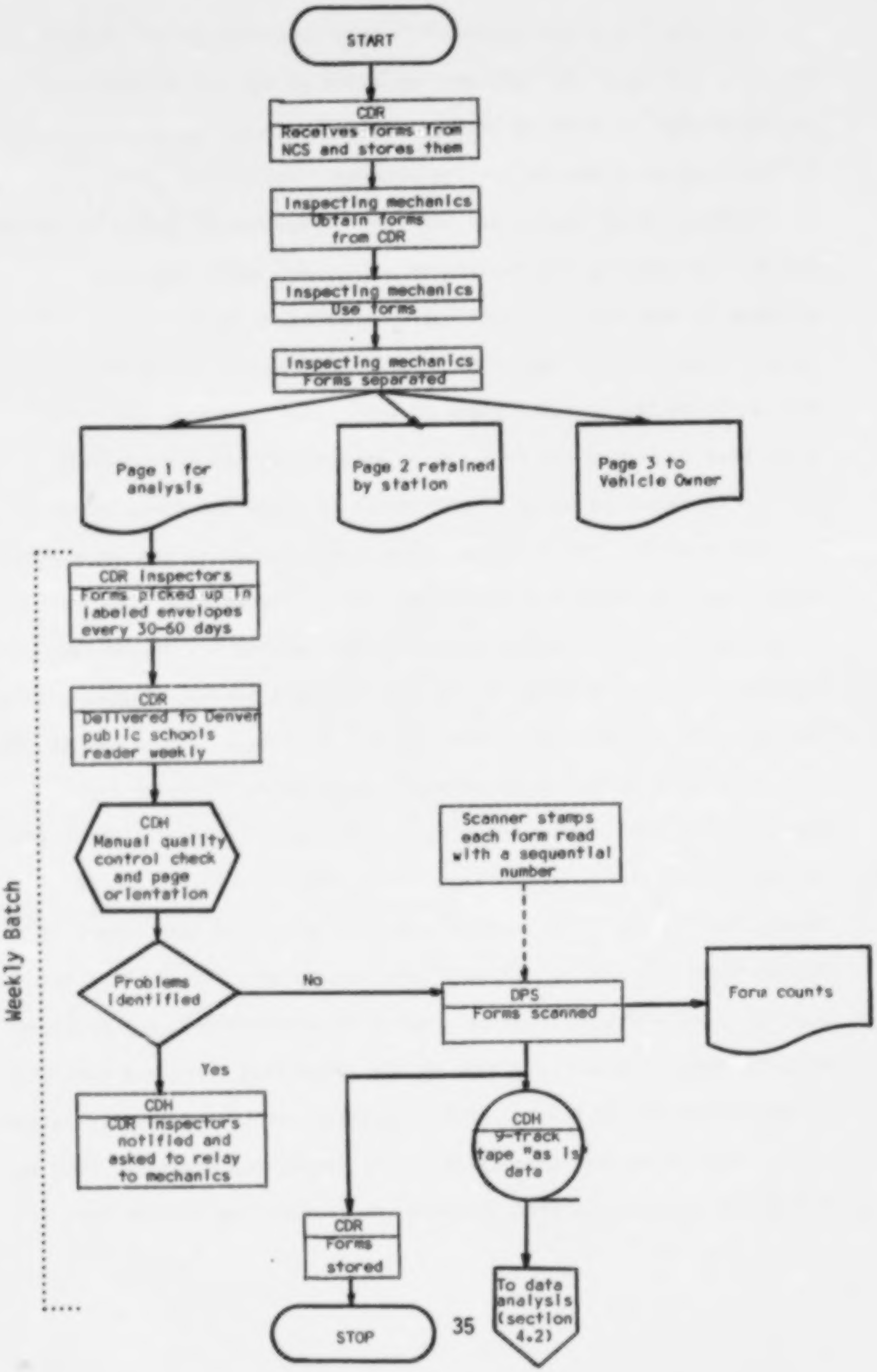
There are portions of other training program costs (proctoring the tests, for example) which could be attributed to training for the inspection form, but these costs are minor and would be incurred whether or not the inspection form were included in the training.

3.3 Data Input

Data input is the process by which the inspection forms are obtained by the licensed mechanics, retrieved by the Department of Revenue (CDR), data captured from the form and analyzed. Figure 2 diagrams this process.

The Department of Revenue (CDR) is responsible for ordering the forms from NCS. The forms are stored by CDR and obtained by the mechanics from the CDR office in Denver when they purchase the window stickers. One form is provided with each sticker. CDR inspectors also carry forms in their vehicles in case a station should need any. Although the forms are consecutively numbered, they are not controlled documents, and no security is required, either by CDR or the stations. There is no charge to the inspection station for the forms. Identification is required when the forms are obtained only if stickers are obtained at the same time.

Figure 2: DATA INPUT
JANUARY 1, 1982 TO PRESENT


START
CDR
Receives forms from NCS and stores them
Inspecting mechanics
Obtain forms from CDR
Inspecting mechanics
Use forms
Inspecting mechanics
Forms separated
Page 1 for analysis
Page 2 retained by station
Page 3 to Vehicle Owner
CDR Inspectors
Forms picked up in labeled envelopes every 30-60 days
CDR
Delivered to Denver public schools reader weekly
CDH
Manual quality control check and page orientation
Weekly Batch
Problems identified
No
Yes
Scanner stamps each form read with a sequential number
DPS
Forms scanned
Form counts
CDH
CDR Inspectors notified and asked to relay to mechanics
CDH
9-track tape "as is" data
CDR
Forms stored
To data analysis (section 4.2)
STOP

After the inspection process has been completed by the mechanic, the three sheets of the form are separated at the top perforations. The third page is given to the motorist; the second page is retained by the inspection station for its records. Inspection stations are told to store their copies for one year. Page one is picked up during the regular audit by the Department of Revenue (CDR) inspector assigned to the station. Audits are mandated to occur no less frequently than every 60 days, but in practice the CDR inspectors have been auditing the stations every 30 days. Any questions the mechanic might have regarding the form can be answered by the CDR inspector, but the inspector is under no obligation to check the forms collected from the station. The collected forms are returned to the Department of Revenue (CDR) office in Denver and are delivered weekly to the Denver Public Schools (DPS) scanning site. Nadine Quigley of the Department of Health (CDH) Mobile Sources staff assumes responsibility for data handling from this point until a data tape is provided to CDH Data Services. At the scanning site a Department of Health (CDH) Mobile Sources data clerk conducts a manual quality control check (for obvious tears, etc.) and orients each page for reading by the NCS Sentry 7010 optical mark reader. When the projected data volume of 20,000 forms per week is achieved, the volume will dictate that the quality check preceding machine reading be perfunctory. Any problems with the completion or condition of the inspection forms are reported to the Department of Revenue (CDR) inspectors weekly on a notification slip. They relay the information to the inspection stations, sign to verify the station has been informed, and return the slip to the

Department of Health (CDH). Serious and consistent problems can also be relayed to the mechanics' training program as a suggested revision to the instruction on completing the inspection forms.

Significant differences between the "blue" and "green systems" are apparent at the "forms scanned" stage. The data input system designed for the July-December ("blue") phase concentrated editing at the Sentry 7010. The reader attempted to scan each form. Forms which could not pass through the reader were ejected into a bin. Forms which physically could be scanned were then read and problems identified. A "problem" embraced data missing or not readable, data out of range, and conflicting data. The forms were shunted into the rejection bin if a serious enough problem was found. The Department of Health (CDH) had established (and could alter) criteria by which the scanner judged the severity of the errors. A numerical coding system identified the types of errors found, and the appropriate code was stamped by the machine on the back of the rejected form. Forms judged by the scanner to include accurate data were scanned, stamped with a sequential number, and deposited into a separate bin. They were then ready for boxing and storage by sequential number. Although very "efficient" data were captured with this system, data useful for some purposes were lost. Data containing fatal errors were not captured on the computer tape; a check to ascertain if forms with errors were representative of the entire data base could only be accomplished manually. The limited computer capability of the optical mark reader was also taxed with the error identification codes, so error categorization failed to be as complete as hoped.

Redesigning the data handling system for the full-volume ("green") phase of the AIR Program provided an opportunity to eliminate several of the problems noted above. The editing was transferred from the mark reader to the computer. Data are captured from every form which can possibly pass through the scanner, and the computer assesses and notes the accuracy of the data. In this fashion the most complete data bank possible is created. A computer check can then be made to test whether errors are randomly distributed. This procedure captures a greater amount of data, and as a result of a sophisticated error identification system (section 4.2), even data with questionable errors are usable for selected purposes.

There exists an underlying question at this point which could perhaps be titled "The Ethics of Data Capture." Should a form which obviously contains errors undergo correction? Or is it to be preserved as is because it represents a significant statistic? If it is to be corrected, can one be sure the alterations are correct? Colorado has not elected to correct invalid forms. The volumes and types of errors are indications of the "state of the AIR Program" and are significant in themselves.

The inspection forms are technically "source documents" and originally had to be retained for at least two years. The Department of Health (CDH) feels that a storage time of 90 days or until CDH is confident of the data tape accuracy is sufficient. Provided that the data tape is accurate, this decision is reasonable: to physically locate an inspection form would probably require three days' search time. To find the computer record for that form takes a matter of minutes. Handwritten information on the form (owner's name and address, VIN, sticker number) is not essential for the automated data system.

One week is allowed for the scanning process. A new batch is begun weekly. During the July-December ("blue") phase, the batch size averaged 3,000-5,000 forms. Three months into the "green system," the volume had developed to more than 20,000 forms per week. The projected volume was 20,000 forms per week. Without an efficient data handling system, a program of this magnitude would be floundering in a sea of forms and data.

3.4 Readability

Readability is one component of the overall "completion rate." If the mark sensor accepts the form for scanning, it is classified as readable. The other component of the completion rate, the integrity of the scanned data, is discussed in sections 4.1 and 4.2 of this report. If the form jams in the machine, if the form is torn so that the sensor cannot scan it, or if critical form marks (bias bar, skunk marks, timing marks, etc.) are marred, the scanner rejects the form. Common problems which cause forms to be rejected include the following.

- The service writer staples sheets of paper to the inspection form for the mechanic or the cashier. Action: greater emphasis in training and public awareness on handling the forms; instruction at troublesome stations by the CDR inspector.

- Inspecting mechanics or service writers attach other AIR Program documents to the inspection form. Action: this problem virtually disappeared when the full-volume phase began January 1, 1982. Prior to that, the Department of Revenue DR 1390 form was required and was frequently stapled to the inspection form.

- Inspecting mechanics or service writers tear the form when trying to separate the three pages at the perforations. Action: no action yet, although thought has been given to removing the critical form marks from their proximity to the perforations. This could be accomplished either by moving the perforated stub to the right side or the bottom, or by moving the critical form marks to the opposite side and end and keeping the stub at the top.

Grease and dirt from the garage environment do not represent a significant impediment to a high readability rate. An optical mark reader can cope with small amounts of grease and dirt as long as they do not appear in critical areas. A plastic template or overlay has been considered for use with the inspection forms. Its primary purpose would be to guide the mechanic through the data blocks, rather than to keep the form clean. Because few problems have been met which the template could or needed to mitigate, and because of other priorities, the template has not been developed.

Quality control checks exist to promote a high rate of readability. When the Department of Revenue (CDR) inspectors conduct the regular inspection station audits, they have opportunities to answer any questions the mechanics may have. Although it is not required, the inspectors can spot check the forms at the stations to screen the worst problems. A second quality control check occurs when the forms are tallied, spot checked, and oriented for mechanical reading. The forms are still in order by station so obvious and consistent errors can be traced to the station. Problems are referred to Department of

Revenue (CDR) inspectors for discussion with the licensed mechanics. General cautions to stations and mechanics may be made through the training classes, the audits by the Department of Revenue (CDR), and the technical bulletins mailed to the stations.

Readability has not proved to be a particularly problematic element of the AIR Program data system. The Department of Health (CDH) Mobile Sources staff estimates that about 95% of the inspection forms were readable during the "blue phase." An estimate is necessary because unreadable forms were rejected into the same bin as forms with data errors, and it was difficult to distinguish between the two types. Unreadable forms average 2.4% of the "green system" volume, ranging from 1.0% to 6.5% on the weekly batches.

4.0 DATA ANALYSIS

4.1 Purpose and Functional Elements

The ultimate purpose of collecting I/M data is to learn how the I/M program is functioning. A well-designed data handling component should be able to monitor data and provide status reports.

The data analysis system developed for the Colorado AIR Program is concerned with the data records read by the scanner and recorded on the computer tape. Forms which were not physically scannable were rejected at the scanner (section 3.4). That process - checking for readability - is conducted by the scanner and for the purposes of this report is not classified as data analysis. Readability is, however, a consideration in determining a general "completion rate." Completion rate could be defined as the quantity of data determined to be useable for reporting purposes. Forms not readable detract from the completion rate. Taped data records which contain errors also lower the completion rate. Accuracy checking is the first function of data analysis and, with readability, the remaining component required to determine the program's completion rate. Once a determination of data accuracy has been made, data analysis can proceed to its concluding phase, that of producing information in scheduled and special reports.

4.2 "Blue System" Accuracy Checking

With the July-December "blue system," the scanner edited the data, discarding data from those forms which contained serious errors. Data arriving at the computer were considered useable. The primary purpose of the computer was to produce information. In July and August 1981, approximately 30% of the incoming data was discarded by the scanner

Preceding page blank

for readability and fatal data errors. Part way through the "blue system" the criteria were relaxed by which the scanner made its decision to accept or discard the data. Mechanics were issuing a certificate of adjustment rather than compliance for vehicles passing after adjustment. Because the emissions levels on forms with this type of error were accurate, the scanner was instructed to accept the data into the data base. Only about 10% of the incoming data was then rejected for readability and fatal data errors.

4.3 "Green System" Accuracy Checking

Figure 3 depicts data handling under the current "green system." A skeletal version of this system is now operating while the remainder of it is being developed. The first two processes (fatal error identification and questionable error identification) check the accuracy of the data. In contrast to the "blue system," these edits are completed by the computer, not the scanner.

The computer first reviews the record for each inspection. If the scanner has indicated insurmountable problems with the data on a form, the record is immediately rejected. Based on the fault chart in Table 3 developed by AIR Program staff, the computer assigns a value to each record according to the number and type of data flaws it finds. The data elements assessed in this phase relate to information required to set emission level standards (cutpoints). The assigned value - the fatal error flag - is entered in one of the two fields reserved for error flags for each record. Error messages relating to processing are printed at this stage if warranted (Figure 4). Using a cutpoint of three and above, the current level of fatal errors appears to be around 7%.

Figure 3: DATA ANALYSIS
JANUARY 1, 1982 TO PRESENT

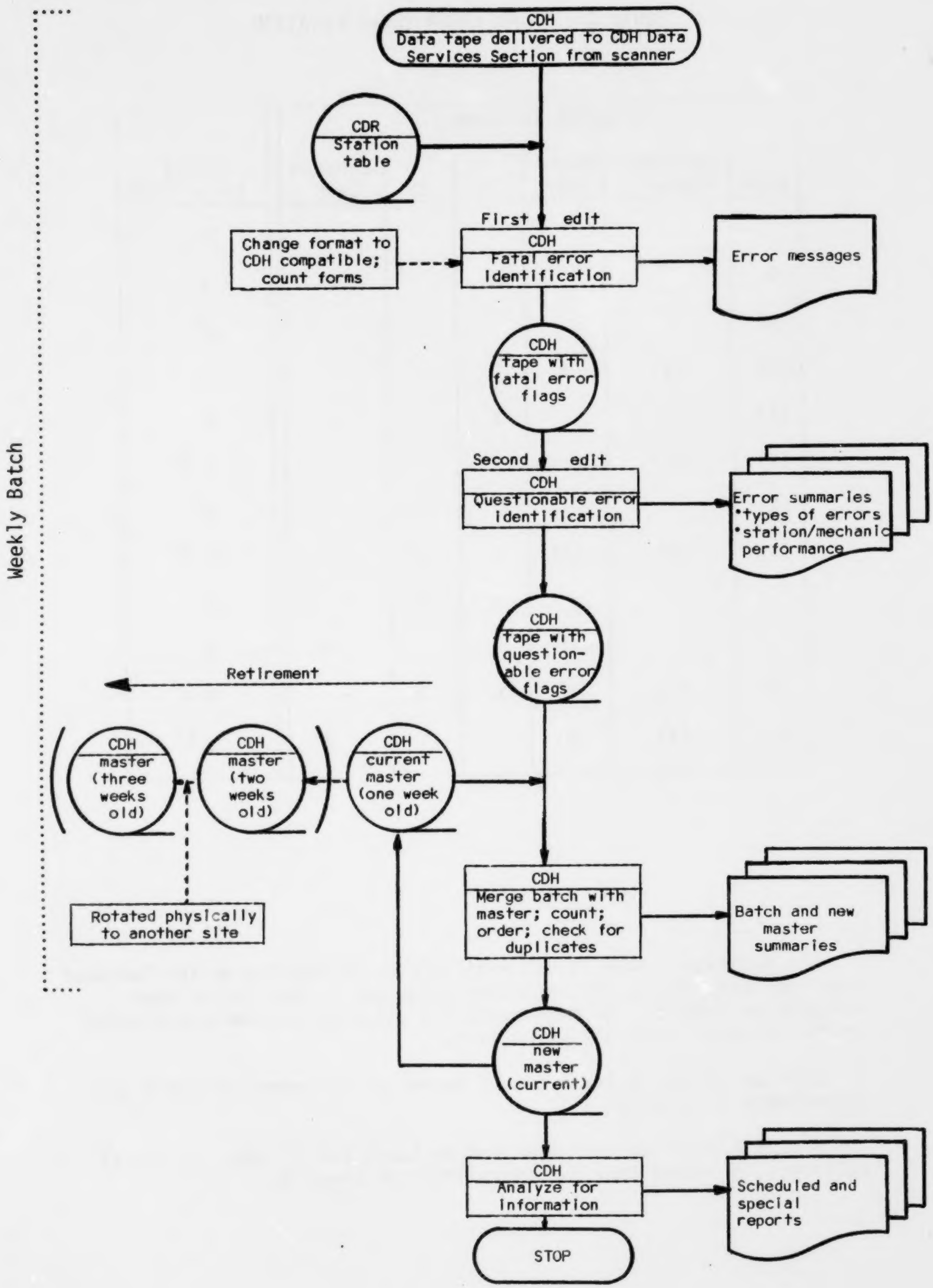

CDH
Data tape delivered to CDH Data Services Section from scanner
CDR
Station table
First edit
Change format to CDH compatible; count forms
CDH
Fatal error identification
Error messages
CDH
tape with fatal error flags
Second edit
CDH
Questionable error identification
Error summaries
•types of errors
•station/mechanic performance
CDH
tape with question-able error flags
Weekly Batch
Retirement
CDH
master (three weeks old)
CDH
master (two weeks old)
CDH
current master (one week old)
Rotated physically to another site
CDH
Merge batch with master; count; order; check for duplicates
Batch and new master summaries
CDH
new master (current)
CDH
Analyze for information
Scheduled and special reports
STOP

Table 3: FATAL ERROR IDENTIFICATION

Value(s) in Error [a]						
Make	Cylinders (Number)	Model Year	HC	CO	Exhaust Leak	Fatal Error Flag
						0
X						1
(X)	X					2
(X)	(X)	X				3
(X)			X			4
(X)	(X)	(X)	X			5 [b]
(X)				X		6
(X)	(X)	(X)		X		7 [b]
			X	X		8
					X	8
(X)	(X)	(X)	X	X		9 [c]
(X)	(X)	(X)			X	9 [c]

---

[a] X indicates value is not available or is invalid or for "exhaust leak" the value is 1; (X) indicates value may or may not be unavailable or invalid. No mark indicates value is available and valid or for "exhaust leak" the value is 0.

[b] HC or CO and at least one of number of cylinders or model year unavailable or invalid.

[c] HC and CO or exhaust leak and at least one of make, number of cylinders, or model year are unavailable or invalid.

Figure 4: PROCESSING SYSTEM ERROR MESSAGES

```
Message 1  SYNTAX ERROR

Message 2  SEQUENCE ERROR

Message 3  DATE ERROR
           CURRENT DATE = MMDDYY

Message 4  MISSING OR INVALID RECORD COUNT

Message 5  AFTER READING zzzzz9 RECORDS FROM THE INPUT FILE AN
           INVALID ID-SEQUENCE NUMBER WAS READ

Message 6  IMBALANCE ERROR

           RECORDS-IN  = zzzzz9
           RECORDS-OUT = zzzzz9
           REJECTED    = zzzzz9

           ENDING ID-SEQUENCE     = 999999999
           BEGINNING ID-SEQUENCE  = 999999999
            DIFFERENCE + 1        = zzzzzzzz9

Message 7  IMBALANCE ERROR

           RECORDS READ-IN   = zzzzz9
           RECORDS EXPECTED  = zzzzz9
            DIFFERENCE        ±zzzzz9
```

NB: A sequence of 9's (e.g. 999999) represents the location of a numeric character string to be generated by the computer. One or more z's preceding the 9's specifies suppression of leading zeros.

Table 4: ERROR/PERFORMANCE REPORT - ERROR SECTION
ERROR DEFINITIONS - PRELIMINARY

NO ERROR FLAGS DETERMINED

NB: Footnotes appear on last page of Table 4.

	'AIR' Form Item #	Questionable Error Flag	Row Value[d]	Out of Range	Multiple	Blank[e]	Non Blank	First Test[f]	Final Test	Final Test Visual	Model Year[g]	Certification[h] Issued	First Emissions Idle	First Emissions 2500	Final Emissions Idle	Final Emissions 2500	'AIR' Adjustment Block	Other[i]
INSPECTION DATA-UNKNOWN																		
VIN	1					X												
License Plate	3				X	X[a]												
Signature	17					X												
Certificate No.						(X						C)[b c]						
or						(X						A)						
Inspection Cost	9			X	X	X												
Test Date - month	4			X	X	X												
day	4			X	X	X												
year	4			X	X	X												
INSPECTION DATA-ERROR																		
Inspecting Cost	9																	1
Test Date (YYMMDD)	4																	2
VEHICLE DATA																		
Make	2			X	X	X												
No. of Cyls.	8			X	X	X												
Model Year	7			X	X	X												
INSPECTION CHECKS																		
First Test - UNKNOWN																		
Visual - yr	10				X	X												
Emissions - P/F	11																	
Idle CO, HC					X	X												
2500 CO, HC*					X	(X					81+)							
First Test - ERROR																		
Visual - yr	10		(82+								81-)							
or			(81-								82+)							

Table 4 continued:
ERROR/PERFORMANCE REPORT - ERROR SECTION
ERROR DEFINITIONS - PRELIMINARY

NO ERROR FLAGS DETERMINED

NB: Footnotes appear on last page of Table 4.

	'AIR' Form Item #	Questionable Error Flag	Row Value[d]	Out of Range	Multiple	Blank[e]	Non Blank	First Test[f]	Final Test	Final Test Visual	Model Year[g]	Certification[h] Issued	First Emissions Idle	First Emissions 2500	Final Emissions Idle	Final Emissions 2500	'AIR' Adjustment Block	Other[i]
INSPECTION CHECKS (cont.)																		
Emissions - P/F	11																	
Idle CO, HC			(P										>stds)					
			(F										≤stds)					
2500 CO, HC*							(X				80-)							
			(P								81+			>stds)				
			(F								81+			≤stds)				
Final Test - UNKNOWN																		
Visual - yr	14				X	(X		F				C)						
or						(X		F				A)						
or						(X		F				D)						
Emissions - P/F	15																	
Idle CO, HC					X	(X		F				C)						
						(X		F				A)						
						(X		F				D)						
2500 CO, HC*					X	(X		F			81+	C)						
						(X		F			81+	A)						
						(X		F			81+	D)						
Final Test - ERROR																		
Visual - yr	14		(82+								81-)							
			(81-								82+)							
Emissions - P/F	15																	
Idle CO, HC							(X	P)										
or			(P												>stds)			
or			(F												≤stds)			
2500 CO, HC*							(X	P)										
or							(X				80-)							
or			(P													>stds)		
or			(F													≤stds)		

Table 4: continued
ERROR/PERFORMANCE REPORT - ERROR SECTION
ERROR DEFINITIONS - PRELIMINARY

NO ERROR FLAGS DETERMINED

NB: Footnotes appear on last page of Table 4.

	'AIR' Form Item #	Questionable Error Flag	Row Value[d]	Out of Range	Multiple	Blank[e]	Non Blank	First Test[f]	Final Test	Final Test Visual	Model Year[g]	Certification[h] Issued	First Emissions Idle	First Emissions 2500	Final Emissions Idle	Final Emissions 2500	'AIR' Adjustment Block	Other[i]
INSPECTION CHECKS (cont.)																		
Adjustment/Repair - UNKNOWN																		
Station Number	12			X	X	(X						A)						
or						(X											non blank)	
Mechanic Number	12			X	X	(X						A)						
or						(X											non blank)	
Adjustment Cost	12			X	X	(X						A)						
or						(X											non blank)	
Repair Cost*	13			X	X	(X					81+	A)						
Adjustment/Repair-ERROR																		
Station Number	12						(X	P)										
Mechanic Number	12						(X	P)										
Adjustment Cost	12						(X	P)										3
Repair Cost	13						(X	P)										
or							(X				80-)							
INSPECTION RESULTS																		
First Test - UNKNOWN																		
Visual - P/F**	10				X	(X					82+)							
Emissions - Levels	11																	
Idle CO, HC				X	X	X												
2500 CO, HC*				X	X	(X					81+)							
First Test - ERROR																		
Visual - P/F**	10						(X				81-)							
Emissions - Levels	11																	
Idle CO, HC																		4
2500 CO, HC*							(X				80-)							4

Table 4: continued
ERROR/PERFORMANCE REPORT - ERROR SECTION
ERROR DEFINITIONS - PRELIMINARY

NO ERROR FLAGS DETERMINED

NB: Footnotes appear on last page of Table 4.

	'AIR' Form Item #	Questionable Error Flag	Row Value[d]	Out of Range	Multiple	Blank[e]	Non Blank	First Test[f]	Final Test	Final Test Visual	Model Year[g]	Certification[h] Issued	First Emissions Idle	First Emissions 2500	Final Emissions Idle	Final Emissions 2500	'AIR' Adjustment Block	Other[i]
INSPECTION RESULTS (cont.)																		
Final Test - UNKNOWN																		
Visual - P/F**	14				X	(X		F			82+)							
Emissions - Levels	15																	
Idle CO, HC				X	X	(X		F)										
2500 CO, HC*				X	X	(X		F			81+)							
Final Test - ERROR																		
Visual - P/F**	14						(X				81-)							
or							(X	P)										
Emissions - Levels	15																	
Idle CO, HC							(X	P)										
2500 CO, HC*							(X	P)										4
or							(X				80-)							4
CERT ISS'D DISAGREEMENT																		
Pass/Adjustment	16/15																	
Other	16/15								(P			A)						
or	16/15								(F			C)						
or	16/12								(P			D)						
or	16/14											(A					blank)	
or	16/13,7									(F		A)						
or	16/12,7										(81+	A						5)
											(80-	D					non blank)	
or	16/12,13,14									(P		D					non blank	6)

Table 4: continued
ERROR/PERFORMANCE REPORT - ERROR SECTION
ERROR DEFINITIONS - PRELIMINARY

*Beginning July 1, 1982.

**Applies to each system (catalytic converter, fuel restrictor, AIR system) individually.

[a] Where more than one error condition occurs on the same line, each condition applies independently (non-exclusive OR).

[b] Where error conditions are enclosed within parentheses all enclosed conditions apply simultaneously (AND).

[c] In cases where one or more error conditions is undetermined it will be assumed that there is no error.

[d] Row Value - value of item to which row applies.

[e] Blank refers to item as a whole.

[f] Test includes both visual and emissions parts unless specified otherwise. P indicates passed both visual and emissions parts, F indicates failed one or both parts.

[g] Model Year - 82+ indicates model years 82 and newer, 81- indicates model years 81 and older. 81+ indicates model years 81 and newer, 80- indicates model years 80 and older.

[h] Certification Issued - C indicates certification of compliance. A indicates certification of adjustment. D indicates certification of denial.

[i] 1 - Inspection cost > $10.
2 - Test date ≥ current date.
3 - Adjustment cost > $15.
4 - CO levels > 15%.
5 - Repair cost < $100 or blank.
6 - Repair cost ≥ $100.

Next the computer reviews each record for questionable errors. The criteria with which the computer is to judge the seriousness of the questionable errors is under development by the AIR Program staff, but a preliminary version is provided in Table 4. The error flag value for each type of error has not been established yet. Basically this system assigns a value of 0-99 to each record. A minor error will be assigned a low number; a significant error, a higher number. Combinations of errors will be assigned still higher numbers. The severity of each error is based on the judgement of the AIR Program staff according to the Program's established data analysis needs. The questionable error flag is entered in the second error flag field for each record. Each record now contains the data which were read from the inspection form by the optical mark reader and two error flags. The first, fatal errors, is for data critical to setting emissions standards (cutpoints); the second is for data with less serious errors (questionable errors), but errors which are indicative of the general reliability of the data on an inspection form.

The two error flags will be used in the following manner. Depending on the purpose of an analysis, two "reliability levels" may be selected. The questionable error flag indicates basically how trustworthy the data on that form are judged to be. The fatal error flag indicates how valid the critical data elements are. A count of the number of inspections on the data tape would include all forms (questionable error flag of 99 or lower, fatal error flag of nine or lower), but an analysis of adjusted emissions by model year might require data rated at 50 or lower, with a fatal error flag of two or lower. Make and model distributions of emissions levels might include a questionable error flag of 10 or lower and a fatal error flag of three or lower. The flags may be altered independently of each other. When operational, this system will provide an indication of how accurate the captured data are. It will allow subdivisions of the data bank based on purpose and degree of accuracy required. It will allow much greater analysis of the accuracy of the data, and thereby enhance the credibility of the analyses produced.

To the knowledge of the Colorado Department of Health (CDH) Data Services Section, the error identification system being developed by the AIR Program staff is unique. It is difficult to develop and will require extensive testing. The time and effort involved in developing such a reliability rating system must be balanced against the value of the information gained and the needs of the program. For the AIR Program it promises significantly greater flexibility in handling the data captured by the optical mark reader.

One of the products of the error identification procedures is a series of error reports developed after the second edit. These summarize the types of errors found in the data and organize the information by inspection station and mechanic. Processing error messages (Figure 4) are produced when the records are first checked following receipt from the scanner, but the reports generated after the second edit are the first in-depth administrative reports furnished by the system. Figure 5 is a mock-up of a batch error/performance report under development. The report consists of two sections. The first, the error section, reports the types and quantities of errors the mechanics are making when they complete the inspection forms. Mechanics or stations with high error rates will be marked with

```
                                          Figure 5
  BATCH ID RANGE               C O L O R A D O  D E P A R T M E N T  O F  H E A L T H                    MMM 29, 1999
999999999 - 999999999                        ERROR / PERFORMANCE REPORT                                      PAGE 999
                                                  ERROR SECTION

                    - - - - - - - - - -  (ALL ERROR RATES EXPRESSED AS PERCENT)  - - - - - - - - - - -
                                         - - - - -INSPECTION  CHECKS- - - - -    - -INSPECTION RESULTS- -  CERT ISSUED
STATION                 ITEM   1,3,4,9,      2,                                                            DISAGREEMENT
NUMBER        FORMS     NOS: 17,CERT NO.     7,8    10YR,11PF    14YR,15PF     12,13      10PF,11#S   14PF,15#S      16
      MECH    READ    FORM    INSP DATA      VEH    FIRST TEST   FINAL TEST  ADJ/REPAIR   FIRST TEST  FINAL TEST  PASS
      NO.            ERRORS   UNK    ERR    DATA    UNK   ERR    UNK   ERR   UNK   ERR    UNK   ERR   UNK   ERR   /ADJ  OTHR
1000
      0001     999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9
       Z        Z     Z       Z      Z       Z       Z     Z      Z     Z     Z     Z      Z     Z     Z     Z     Z     Z
      9999     999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

1000  ALL    99999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

1001
      0001     999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9
 Z     Z        Z     Z       Z      Z       Z       Z     Z      Z     Z     Z     Z      Z     Z     Z     Z     Z     Z
1999  ALL    99999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

1XXX STATUS 999999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

2000
      0001     999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9
 Z     Z        Z     Z       Z      Z       Z       Z     Z      Z     Z     Z     Z      Z     Z     Z     Z     Z     Z
9998  ALL    99999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

9XXX STATUS 999999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

9999 ?STA#?  99999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9

ALL STATUS 9999999   99.9    99.9   99.9    99.9    99.9  99.9   99.9  99.9  99.9  99.9   99.9  99.9  99.9  99.9  99.9  99.9
```

Figure 5

```
                                        C O L O R A D O  D E P A R T M E N T  O F  H E A L T H                               MMM 29, 1999
BATCH ID RANGE                                          ERROR / PERFORMANCE REPORT                                            PAGE 999
999999999 - 999999999                                      PERFORMANCE SECTION

                           - - - - CARBON  MONOXIDE - - - - -    - - - - - HYDROCARBONS - - - - -      AVG    LIC ADJMNTS   REQ REPAIRS
STATION                                                                                                INSP   % OF   AVG    % 81+   AVG
NUMBER        FAIL   # OF  AVG EMISSIONS  EM REDUCTION   # OF   AVG EMISSIONS  EM REDUCTION      COST   VEHS   COST   VEHS    COST
       MECH   RATE   VEHS   FIRST FINAL   AVG     %      VEHS    FIRST FINAL    AVG     %
       NO.
              RET    RTST   RTST  RTST    RTST   RTST    RTST    RTST  RTST     RTST   RTST      ---    RTST   RTST   RTST   81+ R
              ALL    ALL    ALL   ---     ALL    ALL     ALL     ALL   ---      ALL    ALL       ALL    ALL    ALL    ALL    81+ A
1000
       0001   99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99
        Z      Z      Z      Z     Z       Z      Z       Z       Z     Z        Z      Z         Z      Z      Z      Z      Z
       9999   99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

1000   ALL    99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

1001
       0001   99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99
 Z      Z      Z      Z      Z     Z       Z      Z       Z       Z     Z        Z      Z         Z      Z      Z      Z      Z
1999   ALL    99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

1XXX STATUS   99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

2000
       0001   99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99
 Z      Z      Z      Z      Z     Z       Z      Z       Z       Z     Z        Z      Z         Z      Z      Z      Z      Z
9998   ALL    99.9   9999   09.9  09.9    09.9   99.9    9999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

9XXX STATUS   99.9 999999   09.9  09.9    09.9   99.9  999999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99

ALL STATUS    99.9 9999999  09.9  09.9    09.9   99.9 9999999    09.9  09.9     09.9   99.9      99.9   99.9   99.99  99.9   999.99
```

asterisks for remedial assistance from the Department of Revenue (CDR) inspectors. The second section, performance, concentrates on consumer protection aspects of the inspections and adjustments. By comparing the performance of a mechanic or a station with the average performance ("ALL STATUS"), the quality of adjustment and repair can be monitored. Again, asterisks will flag abnormal rates. Copies of the batch error/performance report will be distributed to Department of Revenue (CDR) inspectors, who will conduct field visits at those stations indicated on the report as having aberrant error or performance rates.

The last stage of accuracy checking in the "green system" occurs when the batch data are merged with the master, or entire extant, data bank. The master tape used is the computer tape generated when the immediately previous data batch was merged; it is one week old. Two back-up copies of the master tape, two and three weeks older than the master, are retained. The three week old tape is rotated to a separate storage vault each time a new master tape is created. At the most, three weeks' worth of inspection forms would have to be rescanned to recapture data in case of a catastrophe. When the batch tape is merged with the master, the program counts the number of records, puts them in order by the sequential scanner number, and checks for duplicate sequential numbers. This phase produces error condition reports. Figure 6 is a mock-up of a graphic description of the quantities and types of errors found in both the batch and new master data files. It reports the number of records found unreadable ("bad scans"), then depicts each type of error as a section of the "pie." For quick reference purposes graphic depictions are very useful.

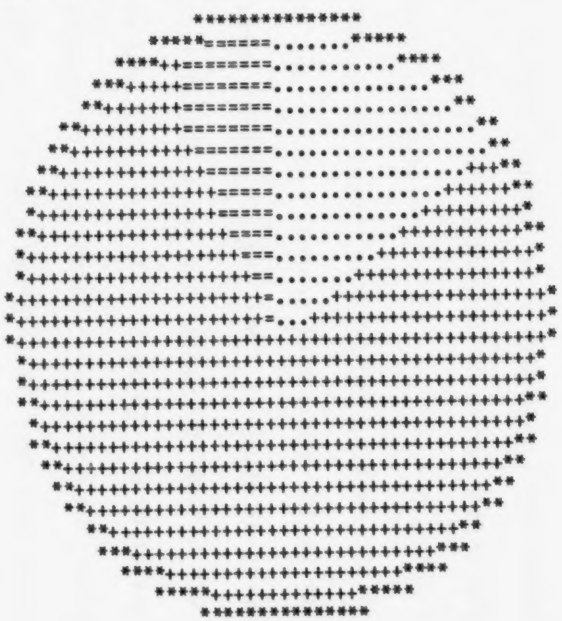
The accuracy checking accomplished by the "green system" identifies abnormalities based on statistical assurances. The abnormalities can

```
REPORT DATE                                  Figure 6
XXX Z9, 1999                   C O L O R A D O  D E P A R T M E N T  O F  H E A L T H
                                         INSPECTION/MAINTENANCE PROGRAM
                                             WEEKLY BATCH SUMMARY
```

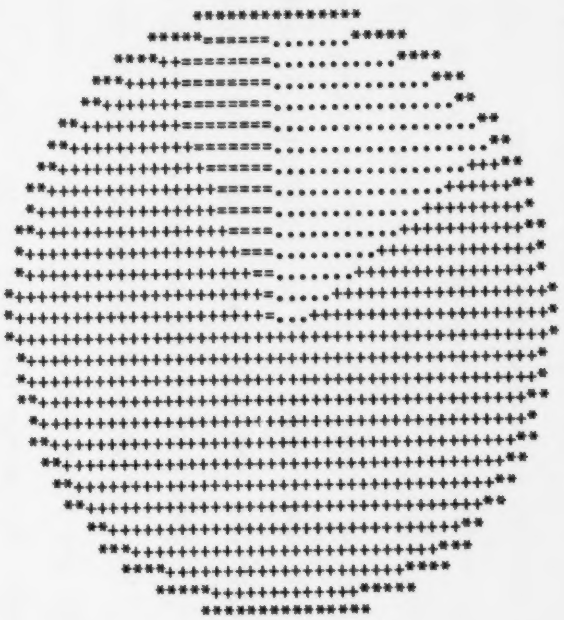
```
           BATCH TOTALS

BEGINNING ID............999999999
ENDING ID...............999999999

RECORDS IN..............zzzzzz9
BAD SCANS...............zzzzzz9
RECORDS OUT.............zzzzzz9

FORMS WITH NO ERRORS......zzzzzz9ᵃ
FORMS WITH QUESTIONABLE ERRORS
AND NO FATAL ERRORS.......zzzzzz9
FORMS WITH FATAL ERRORS...zzzzzz9
```

```
FORMS WITH NO ERRORS      :++++
FORMS WITH QUESTIONABLE
ERRORS & NO FATAL ERRORS:....
FORMS WITH FATAL ERRORS :====
```

```
          NEW MASTER TOTALS
OLD TOTAL RECORDS
NEW TOTAL RECORDS.........zzzzzz9

FORMS WITH NO ERRORS......zzzzzz9

FORMS WITH QUESTIONABLE ERRORS
AND NO FATAL ERRORS.......zzzzzz9

FORMS WITH FATAL ERRORS...zzzzzz9
```



```
FORMS WITH NO ERRORS.........zz9%
FORMS WITH QUESTIONABLE ERRORS
AND NO FATAL ERRORS..........zz9%
FORMS WITH FATAL ERRORS......zz9%
```



```
FORMS WITH NO ERRORS.........zz9%
FORMS WITH QUESTIONABLE ERRORS
AND NO FATAL ERRORS..........zz9%
FORMS WITH FATAL ERRORS......zz9%
```

ᵃ"Forms with no errors" may be either error free or with errors assigned values lower than the cutpoints specified for this report.

rest either with the inspection station or mechanic, in which case it becomes the focus of attention for enforcement, or with the data handling procedures, in which case Mobile Sources and Data Services must correct the procedures. Only extensive testing will prove the full capabilities and reliability of the accuracy checking element of the full volume data analysis system.

4.4 "Blue System" Information Producing

Data analysis for the "blue system" was devoted almost exclusively to providing information. One report, the weekly "AIR Error Report," was custom programmed in COBOL, with the other programs relying on the capabilities of SPSS. The brevity of the "blue system" (six months) precluded extensive custom programming. Appendix G includes a summary of "blue system" reports, copies of two reports, and report schedules. Several bar graphs are also included; these were produced by transferring computer generated summary data to a Hewlett-Packard 85 graphics terminal not operated by the Data Services Section.

4.5 "Green System" Information Producing

With the "green system" three reports will be supplied on a routine basis:

monthly	station performance
bimonthly	model year performance
quarterly	distributions and test results

In most cases the type of information provided regulates the frequencies at which the reports are produced. Model year performance can vary so much, for example, that bimonthly reporting compensates for short-term variances. While the complete data analysis for the "green system" is being developed, interim reports are provided on a frequent basis using a preprogrammed software package. Report topics include:

1. emission reduction,
2. pass/fail rates on the entire data base,
3. retest rates,
4. the number of vehicles failing in the first and second test.

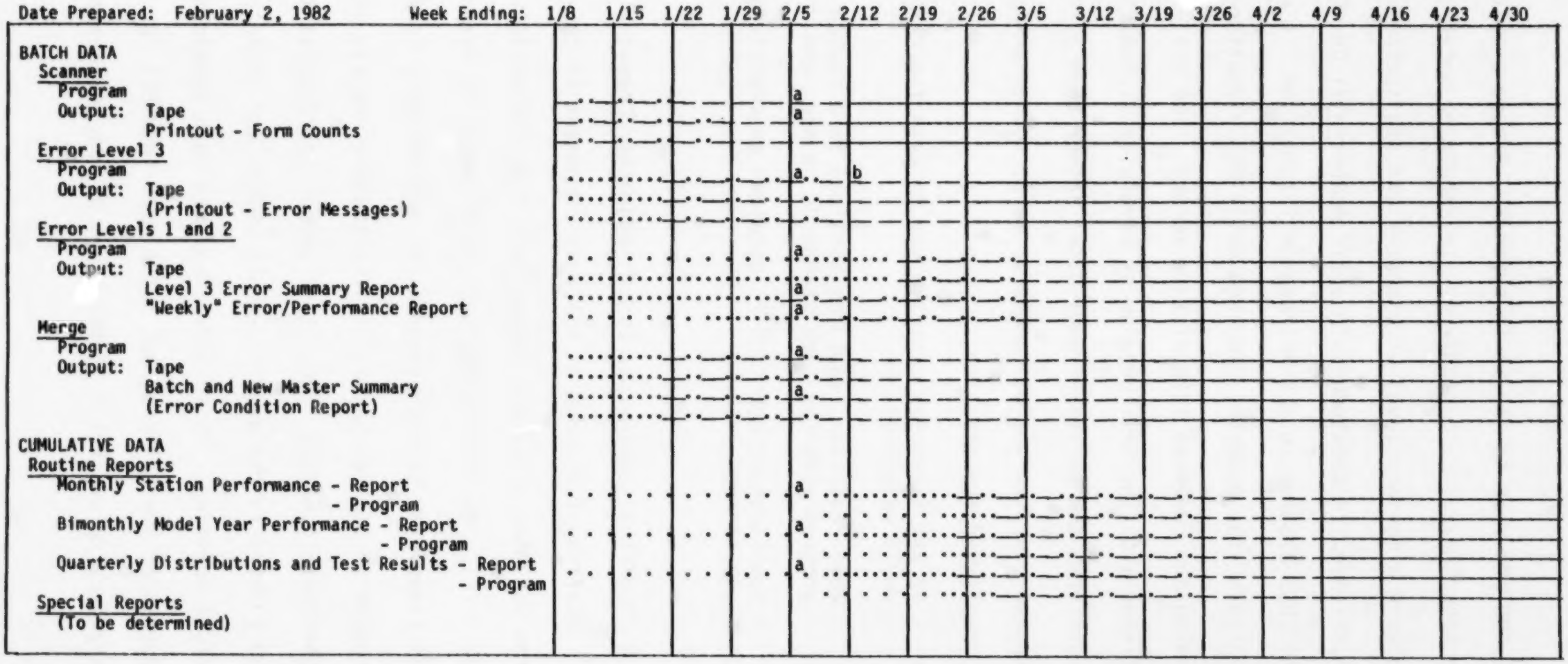
All of the programming mentioned so far, except that for the interim reports, has been custom written for the needs of the AIR Program. Developmental time, as shown in Figure 7, can be quite lengthy, and unexpected delays can easily double the amount of time required. Using preprogrammed software can decrease the burden placed on the programming staff. The AIR Program relies on one of the available software packages, the Statistical Package for the Social Sciences (SPSS),[2] for almost all requests for special reports. SPSS is a package designed for social science data but is useful in most fields. It is excellent for data manipulation, provides for flexible labeling and saving of data files, and is especially valuable when many different analyses are to be run on the same data. Its capabilities include descriptive statistics, contingency tables, regression analysis, partial correlation, analysis of variance, discriminant analysis, and factor analysis. The AIR Program staff finds the SPSS package somewhat less efficient than other packages when used to perform significant numbers of calculations or data transformations. Costs for programs like SPSS vary greatly; $3,000 originally and

---

[2] SPSS is a trademark of SPSS, Inc. of Chicago, Illinois, for its proprietary computer software. No materials describing such software may be produced or distributed without the written permission of SPSS, Inc.

Figure 7

DATA ANALYSIS PROJECTIONS



Concept . . . Design ..... Development __.__ Testing __ __ __ Operational ______

[a] Awaiting approval by Mobile Sources Section

[b] To be revised when Department of Revenue adds mechanic numbers to tape.

$1,000 per year to use it is typical. A more complete description of SPSS appears in Appendix H. It should be noted that SPSS does require a certain level of computer and statistical knowledge and experience. A knowledgeable staff member will be able to manipulate the SPSS program to extract needed information. A recent AIR Program analysis, for example, compared emissions reductions of models with sealed and unsealed idle mixture screws. The analysis was accomplished with the SPSS program by carefully excluding makes and model years from the pertinent data base, rather than by custom designing a program over two to four weeks or more. Other analyses which can be accomplished include:

- if all inspected vehicles had to pass for carbon monoxide, what would reductions be,
- what reductions would be obtained in a carbon monoxide only program with the same standards as now, and
- how large a reduction is obtained on vehicles still failing after adjustments.

4.6 Staffing, Equipment, Costs, and Other Computer Systems Considerations

Staffing for the data analysis component of the AIR Program comes both from CDH Mobile Sources (three Full Time Equivalents) and CDH Data Services (one FTE). One Mobile Sources staff member is responsible for data functions. He is a programmer and additionally is familiar with the I/M program in general so he can, for example, design the fault chart for the questionable errors. One other member coordinates the data collection and a third is the data clerk who checks and orients the inspection forms before scanning. Three individuals in Data Services have contributed to aspects of the AIR Program. With their one FTE for the AIR Program they provide expertise in the areas of the NCS scanner, COBOL, SPSS, statistics, and general project supervision. As the AIR Program completes developmental activities, the four FTE's should decrease to two FTE's. Programming will decrease to a minimum, requiring only a part of a Mobile Sources FTE and no Data Services FTE. Although the data clerk will be busy, .5 FTE of the data coordination position should be available for other duties.

The Colorado AIR Program uses a Data 100 (Northern Telecom) system as a remote job entry (RJE) station. This system accepts jobs for the central processing unit and prints reports. It should be noted that the standard report graphics are being printed on a non-graphics terminal. This complicates programming tremendously for pie charts. Some bar graph programming had been developed for another project and is being applied to this project. An IBM 3033 functions as the mainframe. Actual analysis occurs here, although the IBM 3033 is not known as a system especially adept at numbers analysis. As the data files increase in size, processing time may become lengthy. Some general concerns for computer systems needed to handle projects like the AIR Program are as follows:

- Can the system handle large files?
- Is the operating speed acceptable for the types of analyses to be accomplished and the types and volumes of data to be analyzed?
- Can the system support SPSS or one of the other statistical packages available?
- What types of storage are available on the system?

The AIR Program data system is handled in weekly batches for data update. All data are stored on tape and are batched, rather than being stored on-line on disk. This greatly reduces the costs of the data system. January 1982 is not a representative month for data costs because full volume analysis had not begun and the data base was small. It does serve, however, to indicate the savings afforded by a batch system. Costs, excluding SPSS costs, totaled $163. Central processing unit (CPU), or actual analysis, time was only $20 at a rate of $263 per hour. $93 of the $163 was for program development; part of the remaining charges was for hanging 22 tapes during the month. On-line charges for a similar amount of effort could have been six to eight times as much, and storage costs for the 80,000 to 100,000 records on file in January could have been considerable. As a data system develops, costs are expected to increase with the volume of data on file and the increased amount of processing time required to analyze the data.

4.7 Administrative Detail

All data analysis requests, whether from the Department of Revenue, the Legislature, or reporters, are handled by the Department of Health. Routine reports are typically for purposes of enforcement or program administration (setting standards, reviewing reductions, etc.) and are provided to agencies and groups as needed. Included are the Air Quality Control Commission, Department of Revenue, Legislature and legislative committees, EPA, County Health Officers, and media representatives.

The only serious problem encountered in the data analysis component of the AIR Program has been that of scheduling. It has proved extremely difficult to accurately estimate how long to allow for developing programming. Because Mobile Sources and Data Services work together closely, coordination of their efforts to eliminate waits on each other has seemed to present the worst problem. Problems associated with equipment failure, illnesses and vacations, and programming difficulties are to be expected. Extra time needs to be built into planning schedules to accommodate for them. If contracted equipment is being used, extra time should be allowed for data staff to become familiar with it.

5.0 SUMMARY

5.1 Description

The Colorado Automobile Inspection and Readjustment (AIR) Program uses machine readable forms to collect emissions inspection and readjustment data. This makes it unique among inspection/maintenance (I/M) programs currently operating. Reliability and cost of the optical mark reading system were the primary reasons for using it rather than other automated systems. Over 3,000 licensed mechanics have been trained to complete the hand-coded inspection form. The forms are collected during monthly station audits by Colorado Department of Revenue (CDR) inspectors. The services of a NCS Sentry 7010 optical mark reader operated by Denver Public Schools have been contracted to scan the forms, converting the data from handwritten marks to a computer tape. Data on that tape are analyzed by a state operated computer, an IBM 3033. Reports are available at regular intervals to satisfy the two primary questions regarding the AIR Program:

- are consumers being adequately protected, and
- are the desired emissions results being achieved?

Special reports are available upon request and are produced with a pre-programmed statistical package, the Statistical Package for the Social Sciences (SPSS).

The I/M program in Colorado has been implemented in three phases. The earliest consisted of data gathering from studies, conducting a limited number of voluntary inspections, and developing a mechanic training program. The AIR Program came into being with Senate Bill 52 and became operational July 1, 1981 (phase 2). This six month phase

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included aproximately 140,000 vehicles which were fleet operated, new registrations, or vehicles undergoing change of ownership. The July-December 1981 program is referred to as the "blue system," from the blue inspection form. The "blue system" afforded the AIR Program staff opportunities to test procedures and regulations before the full-volume I/M program began January 1, 1982.

The third phase of the program, called the "green system" because of the green inspection form, is now partially operational. About 1.4 million inspections will be conducted annually at a projected volume of 20,000 inspections per week. The quantities of forms received and scanned have varied from a rate of around 3,000 per week in January, to 11,000-12,000 in early March, to over 20,000 forms per week in mid-April. Data on the resulting data tape undergo computer analysis, but the full report schedule is not yet operational. A sophisticated error identification system is being developed which will make the captured data more useable and also provide a "reliability factor" to the analyses. This error identification is the most significant change between the "blue system" and the "green system." Both of the systems have been surprisingly successful in capturing data, as well as in capturing seemingly accurate data. When the "green system" is fully operational it will be able to report just how accurate the data records actually are.

5.2 Critical Aspects of the AIR Program

The most serious problem experienced by the AIR Program appears to be that of projecting the developmental time needed by various components of the program, especially data analysis. Because it is an innovative program, it is difficult to foresee where more time should be built into the projections. Involving several groups (CDH, CDR, Air Quality Control Commission) in aspects of the AIR Program means that no single resource can be assigned to all activities. Each activity must be coordinated so that it is accomplished as its priority requires and as the several resources are available. All of the resources need to be flexible. Program changes can - and should - be initiated internally as problems are discovered and solutions are found. Changes can also come from outside sources in the form of legislative action. A viable I/M program can respond to specific changes with a minimum of disturbance to the rest of the program. Training the mechanics to complete the coded inspection form has proved valuable, whether one-on-one as was done in the earliest stages of the AIR Program by CDR inspectors or in classes as has been done for roughly two-thirds of the program. Training appears to have contributed significantly to the high readability rate of the forms.

One measure of the success of a data handling system can be strictly numerical: how much information is gathered and useable? The "green system" scans data from more than 20,000 hand-coded inspection forms each week. On the average, only 2.4% of the forms are lost because of readability problems. Of the remaining 97.6% of the data, only 7% contains fatal errors when the fatal error cutpoint is established at three or above. Neither this 7% nor any percent of the data identified as containing questionable errors (when that system is operational) will be eliminated from the data base. The full 97.6% volume is available for analysis by sliding the fatal and questionable error cutpoints on their respective scales according to the types of analyses needed. A large volume of inspection data is collected and an unusually high percentage of that data is successfully captured for data analysis.

Another measure of success relates to what is done with the useable data: does data analysis meet the reporting needs of the program? Again the AIR Program seems successful. The inspection forms are approximately 30 days old when received for processing. Ten days are used for processing each batch completely. Data results are therefore no more than two months old. Custom programming produces in-depth reports for each batch and on a routine schedule. Using a pre-programmed package such as the Statistical Package for the Social Sciences (SPSS) allows a great deal of flexibility for special reporting.

The Colorado AIR Program has been, and continues to be, developed through a "learn as you go" process. This seems to be the key to its vitality today. The data system efficiently collects emissions data and processes those data to provide up-to-date information for a variety of needs. The primary purpose of an I/M data system is to answer the question, "How well is this I/M program operating?" By its own example the Colorado AIR Program data system gives credence to the answers it provides.

APPENDIX A

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The following text is from the most recent (August 7, 1981) draft of the Arthur Young & Company information system report for the Colorado Air Pollution Control Division. Only those sections pertaining to the I/M program subsystem have been reproduced here.

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2.5 MANAGEMENT INSPECTION/MAINTENANCE PROGRAM

2.5.1 Introduction

On July 1, 1981 Colorado's vehicle inspection and maintenance (I/M) program will begin on a change-of-ownership basis. Mandatory inspections for all affected vehicles in the nine-county I/M program area is tentatively scheduled to begin on January 1, 1982. Relevant details of the program are described below:

- All 1968 and later light duty vehicles in the program area must receive a certificate indicating compliance or adjustment with the I/M program as a prerequisite to the current safety inspection.

- The emissions inspection will be conducted in licensed private garages. Vehicles with emissions exceeding the standards or "cut points" established for a particular model year must be adjusted by a licensed mechanic according to manufacturer's specification in order to receive a certificate (or if the adjustments are conducted by someone else the vehicle must "pass" on a retest).

- Regardless of who makes the repairs, a second test is performed on all vehicles which are repaired. The purpose of the retest is to indicate the change in carbon monoxide and hydrocarbon levels over the first test.

- The program is designed to fail no more than 40 percent of the model year 1968 through 1974 vehicles and 30 percent of the 1975 and later vehicles.

- The program will be administered by the Mobile Sources Section of the Colorado APCD in conjunction with the Colorado Department of Revenue (which currently administers the annual vehicle safety inspection program).

- APCD is responsible for training Department of Revenue personnel to audit inspection and repair facilities, to train inspectors and mechanics, and to provide program surveillance. APCD also must continually reevaluate cut points to avoid exceeding the 40 and 30 percent failure rates set as a maximum by the state law (Colorado Revised Statutes 42-4-306-5 *et seq*) which authorizes the program. This law also requires the Air Quality Control Commission to report annually the costs and effectiveness of the I/M program.

These requirements impose a variety of data gathering obligations upon the Mobil Sources Section. Most of these can be handled through a Data Management Program. Exhibit 2.5-1 depicts the data flow which is described below in greater detail.

2.5.2 Information Source

The source of the data is a one-page form which is filled out by the mechanic for each vehicle tested. Exhibit 2.5-2 is the form which is currently being considered. This form will be read by an optical scanner.

2.5.3 Data Collection Activities

The data sheets will be filled out by hundreds of licensed mechanics in the field. The Department of Revenue will supply the mechanics with the forms and will collect the forms on a monthly (or more frequent) basis. Approximately 1.5 million vehicles will be inspected each year.

Typically, the mechanic will begin by completing the items which identify and describe the vehicle (license number, model, engine size) and identify the inspection station, mechanic, date, etc. Both a visual check (an inspection to determine the presence of pollution control equipment and exhaust system integrity), and a tailpipe emission inspection are conducted. The CO and HC emissions are then entered onto the form. If the vehicle passes both inspections, the mechanic checks off the compliance box on the form.

Approximately one-third of the vehicles are anticipated to fail the inspection, whereupon adjustments (and in some cases, repairs) are made and tailpipe emissions retests are conducted. These results and the cost data related to the repairs and adjustments are entered onto the forms.

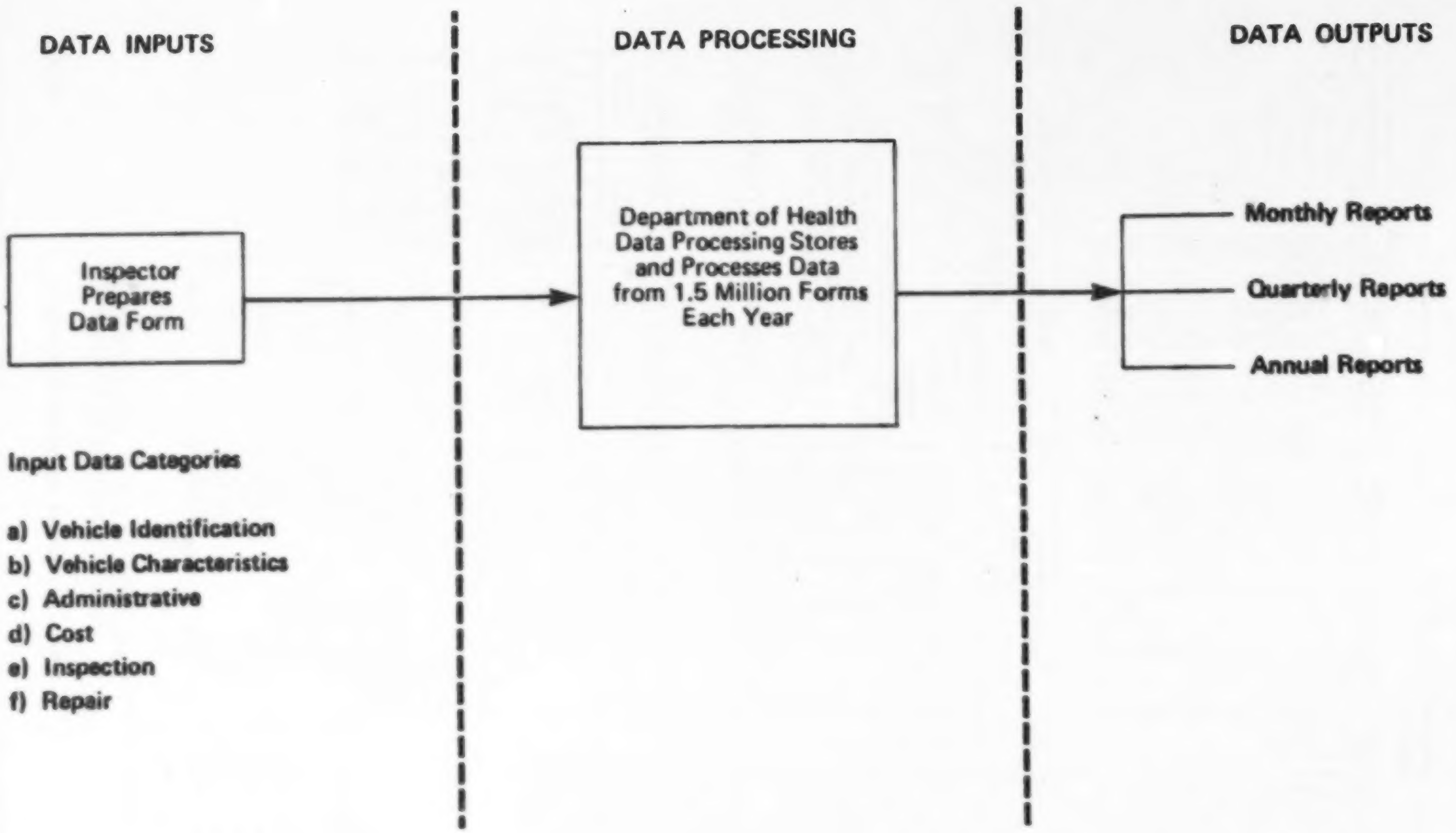
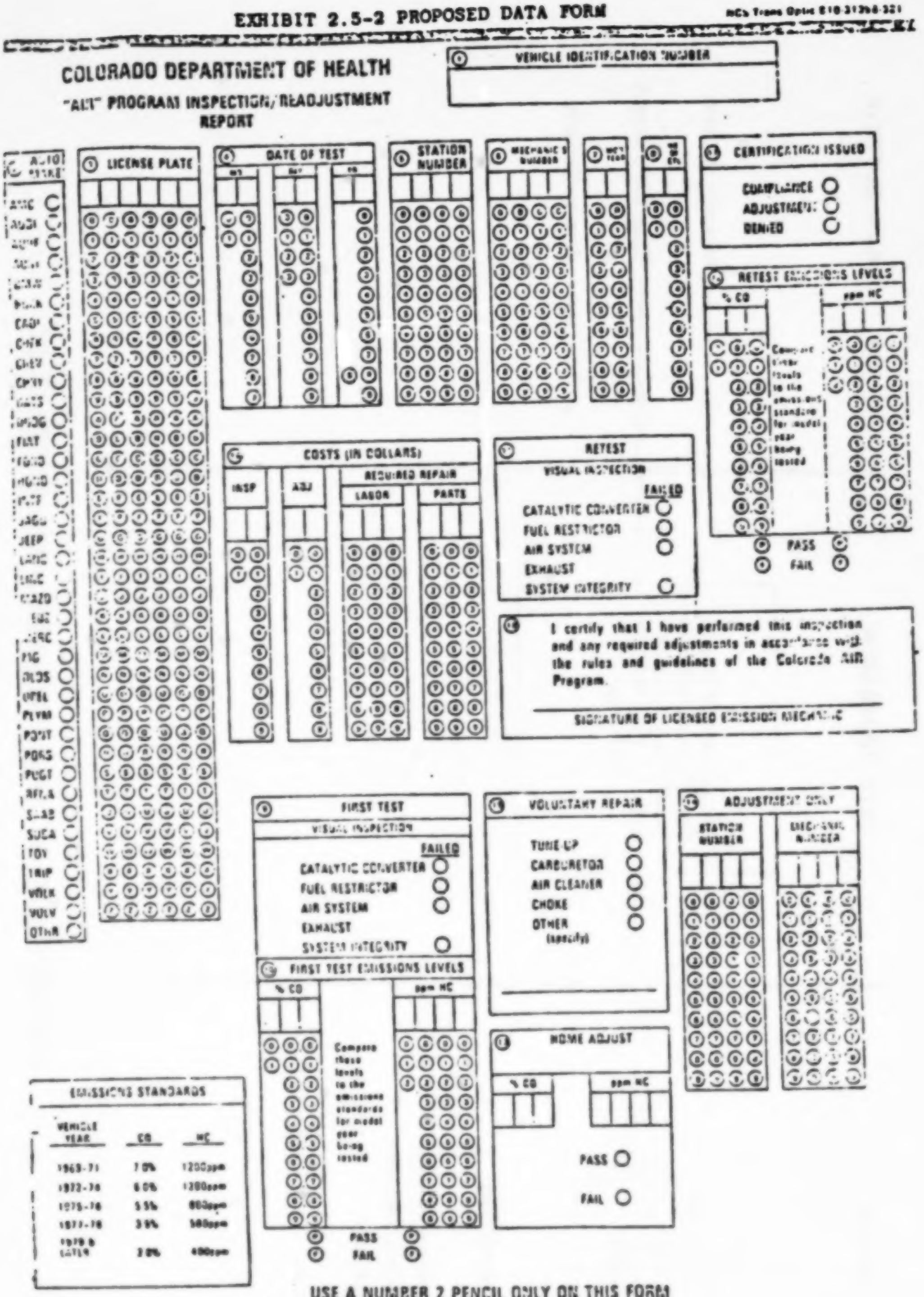

DATA INPUTS
DATA PROCESSING
DATA OUTPUTS
Inspector Prepares Data Form
Department of Health Data Processing Stores and Processes Data from 1.5 Million Forms Each Year
Monthly Reports
Quarterly Reports
Annual Reports
Input Data Categories
a) Vehicle Identification
b) Vehicle Characteristics
c) Administrative
d) Cost
e) Inspection
f) Repair

EXHIBIT 2.5-1. I/M PROGRAM MANAGEMENT
DATA FLOW DIAGRAM

EXHIBIT 2.5-2 PROPOSED DATA FORM



NCS Trans Optic E10-31366-321

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE

AMC ○
AUDI ○
[illegible] ○
[illegible] ○
[illegible] ○
BUICK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
[illegible] ○
JAGU ○
JEEP ○
LAND ○
LINC ○
MAZD ○
[illegible] ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PEUG ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST
MO DAY YR

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MDL YEAR

⑧ NO. OF CYL

⑬ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑭ RETEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested

PASS ○ ○
FAIL ○ ○

⑨ COSTS (IN DOLLARS)

INSP | ADJ | REQUIRED REPAIR: LABOR | PARTS

⑫ RETEST

VISUAL INSPECTION

FAILED

CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

⑮ I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

⑩ FIRST TEST

VISUAL INSPECTION

FAILED

CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

⑪ FIRST TEST EMISSIONS LEVELS

% CO | ppm HC

Compare these levels to the emissions standards for model year being tested

PASS ○ ○
FAIL ○ ○

⑯ VOLUNTARY REPAIR

TUNE UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER (specify) ○

⑰ HOME ADJUST

% CO | ppm HC

PASS ○
FAIL ○

⑱ ADJUSTMENT ONLY

STATION NUMBER | MECHANIC NUMBER

EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	3.0%	400ppm

USE A NUMBER 2 PENCIL ONLY ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO DEPARTMENT OF HEALTH

PAGE 1

EXHIBIT 2.5-2 **(Page two)**

INSTRUCTIONS TO LICENCED EMISSIONS MECHANICS

(ONLY a Licensed Emissions Mechanic may perform this inspection.)

NOTICE

The first copy (top) of this form will be scanned electronically.

Please keep the top copy free of dirt or grease.

Do NOT fold, staple, spindle, or mutilate top copy.

Do NOT make ANY marks on the top copy other than specified in directions.

You may make notes on the second or third copies ONLY.

Use ONLY a NUMBER TWO pencil on this form.

Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC:

ENTER:	% CO			ppm HC					**DO NOT ENTER:**	% CO			ppm HC			
	0	4	8	0	7	5	0			4	8	0	7	5	0	0

Except for Item ① (Vehicle Identification Number), after the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be just one circle filled in under each box.

FIRST INSPECTION

A. Complete items ① through [illegible].

B. Do the first test visual and emissions inspection [illegible] and [illegible]. (mark PASS or FAIL for CO and HC)

C. If the vehicle passes both the visual and emissions inspection, mark "Compliance" [illegible], sign the form [illegible], punch [illegible] [illegible], and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

D. If the vehicle fails the visual or emissions inspection and the adjustments or repairs are done at your station complete item [illegible] and go on to Step G.

If the vehicle owner wants the work done elsewhere, give him/her the bottom part of page 3 to be filled in by the person who does the work and returned within 10 days for a free reinspection.

REINSPECTION

E. If the vehicle was adjusted or repaired by a Licensed Emissions Mechanic, copy the station and mechanic's license numbers from the "Adjustment Verification" form under item [illegible], attach one copy of the "Adjustment Verification" form to page 2, and go on to Step G.

F. If the vehicle was adjusted or repaired by a non-licensed person, complete item [illegible]. If the vehicle passes, go on to Step G. If it fails, make the adjustments or repairs required and go on to Step G or mark "Denied" [illegible], sign the form [illegible], punch CD [illegible], and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

G. If the vehicle failed the first test visual, do the retest visual inspection [illegible]. If it passed the first test visual, go on to step H.

H. Do the retest emissions inspection [illegible]. (mark PASS or FAIL for CO and HC)

I. Record the amount charged for the inspection, the adjustments (if performed), and the labor and parts costs for required repairs [illegible].

J. Record any voluntary repairs [illegible].

K. If the vehicle passes both the visual and the emissions retests, mark "Compliance" [illegible], sign the form [illegible], punch [illegible] [illegible], and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

L. If the vehicle passes the visual retest but fails the emissions retest (and, for 1981's and newer, $100.00 was spent on emissions repairs) mark "Adjustment" [illegible], sign the form [illegible], punch COA [illegible], and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

M. If the vehicle fails the visual retest (or, for 1981's and newer, fails the emissions retest and less than $100 was spent on emissions repairs) mark "Denied" [illegible], sign the form [illegible], punch CD [illegible], and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

The volume of data to be processed will be large. If each of the 1.5 million vehicles is inspected there will be 1.5 million hard copy forms collected annually. However, not all data elements will be completed on each form because vehicles which "pass" the visual and emissions test are not required to be adjusted and retested. Only about one-third of all vehicles are expected to fail, thus two-thirds (or about 1 million forms) will be partially completed. The type of adjustment or repair and where the repair or adjustment is conducted will determine whether or not other elements are entered on the form.

In Section 2.5.8 (data categorization) estimates of the volume of data to be processed for each data element are given. Based on these estimates, a total of 31.3 million elements will be processed the first year of the program increasing at a rate of about 8 percent per year.

2.5.4 Retention of Data

Completed forms will be delivered to the Department of Health data processing section where they will be read by an optical scanner and the data will be stored on tape. The forms will be stored in a warehouse for at least two years. The tapes will be retained in active storage for one year and retained indefinitely thereafter.

2.5.5 Data Calculation/Processing

The inspection data will be used to produce monthly, quarterly, and annual reports which present the number of failures and emissions reductions by vehicle type, repair station/mechanic, and the program as a whole. These data are processed by the data processing station in the Department of Health. Specific data manipulations are described below:

a) Counts, percentages, ratios, and emissions levels and comparisons for all vehicles tested, passed, and failed by station/mechanic, vehicle type, and totals.

b) Counts, percentages, ratios, emissions levels, reductions, and comparisons; and types of voluntary repairs for vehicles which failed the initial inspection by station/mechanic, mechanic type (licensed at same inspection station, other licensed, or non-licensed), vehicle type, and totals.

c) Adjustment and repair costs for vehicles which failed the initial inspection by mechanic type and totals.

d) Average pass/fail rates and accompanying emissions levels by vehicle type, reason for failure, station/mechanic, and totals.

e) Counts, percentages, ratios, and emissions levels, reductions, comparisons for vehicles which failed the intital inspection by vehicle type and totals.

f) Inspection, adjustment, and repair costs by vehicle type, station/mechanic, and totals.

g) Inspection, adjustment, and repair costs and failure rates by reason for failure, station/mechanic, and totals.

h) Comparisons of current data with historical data for trend identification.

2.5.6 Output Descriptions

Although no final decisions have been made regarding the data output, it appears that there will be a monthly report which will contain tabular data output, a quarterly report comprised of aggregated monthly reports and some analysis of the data, and a formal annual report which will contain extensive analysis and possible recommendations for program changes. These three products are more fully described below.

Monthly Report - This report will probably not be distributed outside of the Department of Health. The purpose of the report will be to monitor the I/M program. It will contain little or no analysis and will probably consist of the following format:

I. The following are tabulated raw data categories:

a) For all vehicles inspected and for each of the following subcategories:

- Vehicles which pass the first inspection.
- Vehicles which fail the first visual inspection (by item, e.g., "missing catalyst" and total).
- Vehicles which fail the first emissions test (by HC, by CO, both and total)
- Vehicles which fail only the visual.
- Vehicles which fail only the emissions.
- Vehicles which both visual and emissions.

The following tabulations are required:

- Number
- Percent of total failed
- Average emissions
- Inspection cost
- Adjustment cost by:
  - Vehicle type (technology group, e.g., 1968-71; model year, make, number of cylinder)
- Station/mechanic
- Totals

b) For vehicles which failed the initial inspection (visual, emissions, visual and emissions, visual only, emissions only, both) and:

- Passed the visual retest
- Passed the emissions retest
- Passed both tests

- Failed the visual retest
- Failed the emissions retest
- Failed both tests.

The following tabulations are required:

- Number
- Percent
- Average initial and retest emissions
- Emissions reductions between initial and retest
- Cost of adjustment
- Cost of labor for repairs
- Cost of parts for repairs (The repair costs should be broken out by category: tune-up, carburetor, air cleaner, choke, and other)

by:
- Repair/adjustment location (same station as inspection, other licensed mechanic, other non-licensed person)
- Station/mechanic
- Vehicle type
- Totals

II. The following derived comparisons will be presented in the monthly report:

a) For vehicles which passed the initial inspection (both emissions and visual) compare the average emissions with all inspected vehicles by vehicle type (technology group, model year, make, number of cylinders) station/mechanic and totals.

b) For vehicles which failed the initial visual inspection (by item, e.g., catalyst, and total) or the emissions inspection (by HC, CO and total) comparisons with the average emissions of all vehicles inspected, all vehicles passed by vehicle type (technology group, model year, make, and number of cylinders) station/mechanic and total.

c) For all vehicles which failed the inital inspection and were adjusted and retested, the before and after adjustment average emissions by vehicle type, location, station/mechanic and totals.

III. For selected raw and derived items comparisons with equivalent data from previous periods for trend identification.

IV. Basic statistical analyses of certain raw and derived data items.

Quarterly Report - This report will probably contain each of the above mentioned items aggregating over a three month period. This report may be circulated outside of the Department to other intested parties (e.g., EPA) and perhaps the general public. The data in item (d) above (failure rates by model year) will be used to "fine tune" the cut points such that the state statutory ceiling on failure rates is not exceeded. Another important item which must be monitored on a more frequent than annual basis is item(g). These inspection station data can be used by Department of Revenue for surveillance and quality assurance. For example, if certain stations are failing or passing a disproportionate percentage of vehicles they will be targeted for close surveillance. The cost data may indicate stations which are exceeding the statutory cost ceilings for inspections and adjustments.

Annual Report - The Air Quality Control Commission is required under CRS 42-4-309 (9)(a) to submit a report annually to the Colorado General Assembly evaluating the overall program. This report, which will be drafted by the Mobile Sources Section, must include data on the costs and effectiveness of the program. The report must specifically indicate the number of vehicles which do not met the cut points after an adjustment has been made. This report will include considerably analysis based upon the monthly and quarterly reports.

2.5.7 Quality Control

This section discusses quality control for the inspection/maintenance data base. A number of checks for invalid data are possible; and these checks fall in several categories, as is indicated below.

A printout should be produced by the computer of any invalid data identified through automatic checks. Then the errors should be corrected if possible, using the original report form to compare the entries in the boxes above and the circles filled in the column below.

(1) Does the entry have a feasible and reasonable value?

A large number of infeasible or unreasonable values may be eliminated by coding the data on forms (Exhibit 2.5-2) with a fixed number of columns and only certain allowable entries per column and by reading the data with an optical scanner. For example, it is not possible to enter the impossible emission value, 150 percent CO, on the form. An automatic or manual check would be beneficial, however, to determine whether no circles or more than one circle were filled in under the same column. Also, the date of test should be earlier than the date on which the data base quality control check was done; this check can be done automatically.

(2) Are the different entries on a single form consistent?

Any consistency check which might reveal an invalid data entry should be made. It should be possible to automate these checks. The following is a suggested list of consistency checks:

(a) Is the model year consistent with (i.e., no more than one greater than) the year of the test?

(b) The certificate status should be consistent with other entries. For example, if the status is "COMPLIANCE," the first or second test emission levels should be within the standards and the first or second test visual inspection should have been passed. If a "home adjust" was performed, requiring compliance with the standards and not only with the manufacturer's specifications, then the "home adjust" Pass/Fail status should be consistent with the reported emission levels and applicable emissions standards.

(c) If the catalytic converter or fuel filler neck restrictor visual inspection was failed, then the year and model of car should be likely to have a catalytic converter.

2.5.8 Categorization of Data

Following are the categories (and in one instance, subcategories) and specific elements of raw data collected. None are derived data. In parentheses is the rough estimate of the total number of elements which are expected to be processed each year based on 1.5 million vehicle inspections in 1982.

1) Vehicle Identification

- License number (1.5 million)

2) Vehicle Characteristics

- Model year (1.5 million)
- Make (1.5 million)
- No. of cylinders (1.5 million)

3) Administrative

- Date of test (1.5 million)
- Inspection station number (1.5 million)
- Inspection station number-for adjustment only (0.1 million)
- Mechanic's number (1.5 million)
- Mechanic's number-for adjustment only (0.1 million)
- Certificate issued (1.5 million)

4) Cost

- Inspection cost (1.5 million)
- Adjustment cost (0.5 million)
- Repair (labor) cost (0.1 million)

- Repair (parts) cost (0.1 million)

5) Inspection

Initital Test Visual Inspection (subcategory)

- Presence of catalytic converter (1.5 million)
- Presence of fuel filler neck restrictor (1.5 million)
- Presence of air system (1.5 million)
- Integrity of exhaust system (1.5 million)

Initial Test Emissions (subcategory)

- CO percentage (1.5 million)
- CO pass/fail (1.5 million)
- HC parts per million (1.5 million)
- HC pass/fail (1.5 million)

Retest Visual (subcategory)

- Presence of catalytic converter (0.5 million)
- Presence of fuel filler neck restrictor (0.5 million)
- Presence of air system (0.5 million)
- Integrity of exhaust system (0.5 million).

Retest Emissions (subcategory)

- CO percentage (0.5 million)
- CO pass/fail (0.5 million)
- HC parts per million (0.5 million)
- HC pass/fail (0.5 million)

Repair

Voluntary Repair

- Tune-up (0.1 million)
- Carburetor (0.1 million)

- Air cleaner (0.1 million)
- Choke (0.1 million)
- Other (0.1 million)

Home adjust (subcategory) (0.1 million)

- CO percent (0.1 million)
- CO pass/fail (0.1 million)
- HC PPM (0.1 million)
- HC pass/fail (0.1 million)

2.5.9 Recommendations

Currently, the I/M program will be administered jointly by the CAPCD and the Department of Revenue. As described above, the CAPCD will gather considerable data from inspection stations on forms which are read by an optical scanner. The Department of Revenue, which will be required to gather operating and surveillance data on a periodic basis, should also report its data (e.g., condition of analyzers) by inspection station. Indeed, the integrity and reliability of the data gathered by CAPCD from the inspection forms is dependent, to a large extent, on the accuracy of the analyzers and the integrity and ability of the mechanics. Station-specific data reported by the Department of Revenue can be correlated to the CAPCD data to enhance surveillance and consumer protection and to identify emissions data which may be inaccurate.

As described in this section, the I/M data to be captured, stored, sorted and reported relates to the programmatic requirements of the I/M program. It is possible that the CAPCD Mobile Sourcess Section will perform FTP testing on a representative sample of vehicles subject to the I/M program to determine the deterioration associated with adjustments. These data could be stored in the data base system and used as emission factors or to revise I/M credits in the MOBILE 2 program. The FTP data can also be used along with the tailpipe emission reductions to determine program effectiveness.

2.5.10 References

1) Senate Bill No. 52, General Assembly of the State of Colorado, (Colorado Revised Statutes 42-4-306.5 *et seq*). Enacted in 1980.

2) Regulation No. 11, "Governing the Motor Vehicle Emissions Inspection Program for the Control of Air Contaminant and Emissions from Motor Vehicles," Colorado Air Quality Control Commission, adopted November 20, 1980.

3) "I/M Data Handling Guidelines Development," work in progress by Radian Corporation for the U.S. Environmental Protection Agency. These guidelines will suggest data which should be generated, captured and analyzed to support local I/M programs.

3.5 VEHICLE INSPECTION AND MAINTENANCE SUBSYSTEM

3.5.1 Introduction

The Vehicle Inspection and Maintenance Subsystem will consist of four major processing modules. Each of these modules are made up of a series of programs or manual procedures normally performed in one continuous flow to perform a specific task. The modules included in the Vehicle Inspection and Maintenance Subsystem are:

- Data Collection and Preparation Module
- Master file update module
- On-line error correction module
- Report preparation module

Exhibit 3.5-1 following this page illustrates the data flow for this subsystem.

3.5.2 Inputs

3.5.2.1 Vehicle Inspection Forms

The primary data input to the I&M Sybsystem is from the vehicle inspection forms. These forms are hand marked by the inspectors and then forwarded to CAPCD for processing. A sample inspection form is shown at Appendix 3.5-A.

All other input to the Subsystem is in the form of corrections to input forms or control and selection data provided to the report preparation module. These inputs will be detailed Section 3.5.5.3.

3.5.2.2 Volumes

The volume of data to be processed will be large. If each of the 1.5 million vehicles in Colorado is inspected, there will be 1.5 million hard copy forms collected annually. However, not all data elements will be completed on each form

VEHICLE INSPECTION AND MAINTENANCE SUBSYSTEM

SYSTEM DATAFLOW

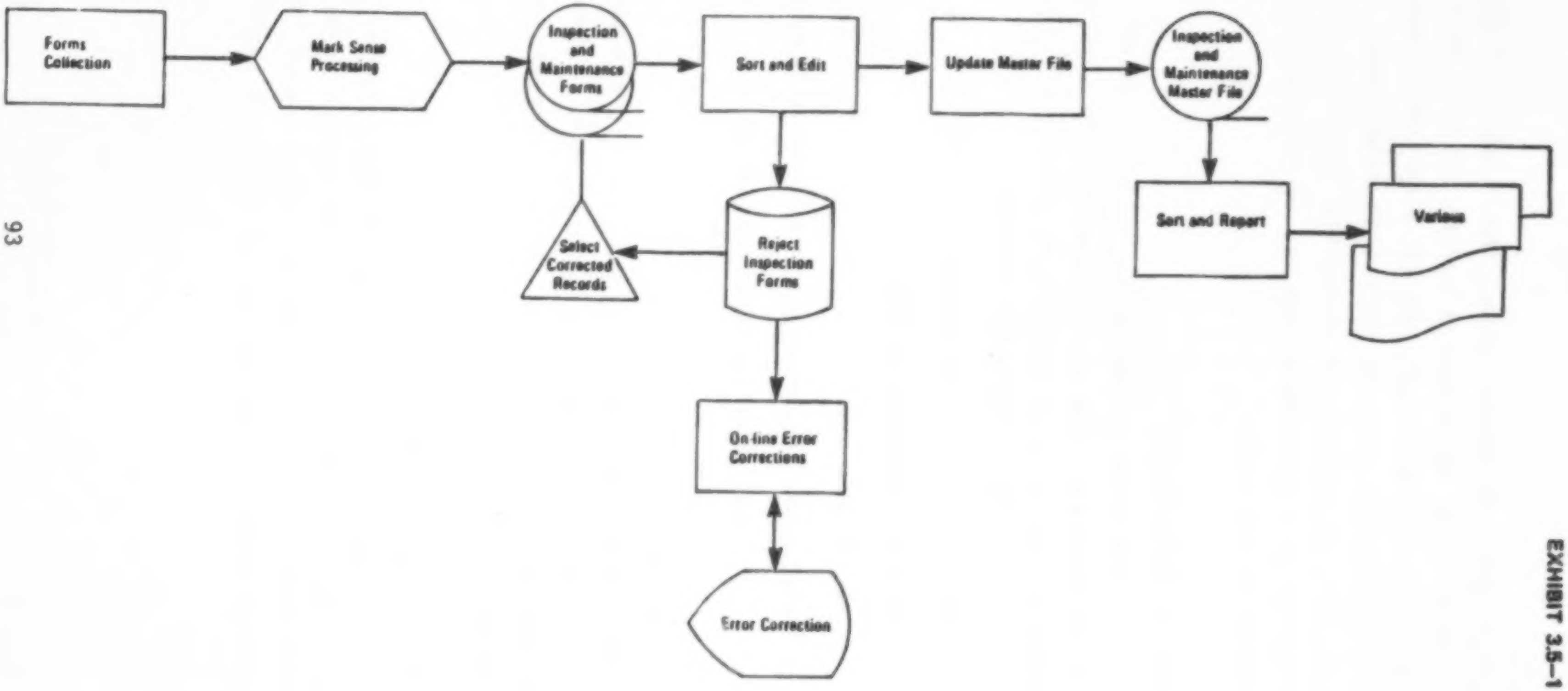

Forms Collection
Mark Sense Processing
Inspection and Maintenance Forms
Sort and Edit
Update Master File
Inspection and Maintenance Master File
Sort and Report
Various
Reject Inspection Forms
Select Corrected Records
On-line Error Corrections
Error Correction

EXHIBIT 3.5–1

because vehicles which "pass" the visual and emissions test are not required to be adjusted and retested. Only about one-third of all vehicles are expected to fail, thus two-thirds (or about 1 million forms) will be partially completed. The type of adjustment or repair and where the repair or adjustment is conducted will determine whether or not other elements are entered on the form.

3.5.2.3 Data Types

The data collected by this system will be divided into five categories. The categories of data include various data elements that will be defined in detail in the data dictionary. the categories include:

- Administrative and control information
- Vehicle characteristics
- Cost data
- Inspection and emission measurement data
- Repair and emission measurement data

3.5.3 Outputs

The outputs and reports from the Vehicle Inspection and Maintenance System would include those reports necessary for file maintenance and those extracts necessary for periodic reporting. Those outputs include:

3.5.3.1 Edit reports

This report would contain the rejected inspection records in a report format similar to the screen format used in the on-line error correction program. This report, ordered by vehicle license number, would allow the clerical staff to review the rejected inspection records, identify the errors, and key corrections into the on-line error correction system.

The report would display each record, grouped by input batches, highlight the errors, and provide sufficient space for over-written notes and corrections. The report would then be used as input to the on-line error correction subsystem.

3.5.3.2 Update control reports

Various reports would be produced by the update programs to provide quantity and quality data to assure a positive control to the updating of the I&M Master File.

Reports produced by these programs should show batch control data such as batch numbers and record counts by batch as well as record counts for the master file before and after updating and number of records posted.

3.5.3.3 Inspection and maintenance reports

Various reports would be produced on a periodic basis. These reports would include data such as:

- 1st test pass/fail statistics
- 2nd test - adjustments or repair statistics
- Type repair statistics

All reports would be formated according to either

- Year, make of automobile
- Year, make of automobile, inspection station

All reports would be available for:

- Monthly statistics
- Quarterly statistics
- Annual statistics
- Special reports/on demand statistics

3.5.4 Data Base Description

The major data files for the Vehicle Inspection and Maintenance Subsystem would be:

3.5.4.1 Input Inspection and Maintenance Forms File

This file would contain the data collected from the inspection forms after it has been processed through the mark sense machine.

The original source documents should be retained, in batches, until that entire batch is successfully posted to the master file. Similarly, the tape file received from the mark sense process, should be retained until all batches on that tape are successfully posted to the master file.

3.5.4.2 Reject Inspection and Maintenance Forms File

This file would contain the records, grouped by batch, rejected by the editing program. These records would be in the same format as the input I&M file, available to be processed in random order, keyed on license number. The batches would be held in the reject I&M file until all records in each batch are free of edit errors, control totals are balanced, and the batch is released for re-processing by the master file update subsystem.

This file is resident on a direct access device and accessable on-line, in random order, by the error correction subsystem. Following an error correction cycle, batch records are processed sequentially, by the edit program.

3.5.4.3 Inspection and Maintenance Master File

The I&M master file would be a complete accumulation of all the inspection data collected year-to-date. As batches are released by the edit program, they are sorted, reformated, updated with the Vehicle Identification Number (VIN) from Motor

Vehicle files and merged into the I&M Master File in VIN sequence.

This file would be a sequential file, sorted by VIN, and stored on tape. The file could be loaded to direct access media for some short-term purpose, but for most reporting purposes, the file would be extracted and sorted from the sequential media in preparation for reporting.

3.5.5 Processing Modules

In this section we will present a discussion of each of the major functions found in each processing module.

3.5.5.1 Data Collection and Preparation Module

3.5.5.1.1 Forms collection and batching - Manual activities would be necessary to provide clean, orderly forms collected and arranged in batches for input to the mark sensing process. In order to assist the clerks in this data preparation effort, one corner of the form should be notched to assist in straightening the forms. Batch control, consisting of a batch number and a count of records in the batch, would also be developed at this time.

3.5.5.1.2 Mark Sense processing - Current plans call for the batches of inspection forms to be sent to the Denver Public School District Data Center where they will be processed and the results returned on standard data processing tape.

3.5.5.2 Master File Update Module

3.5.5.2.1 Sort and edit by batch - This program will sort the input data by batch and record key. The record key could be the vehicle license number or other unique identifier. The editing of each input record would be by criteria as listed in Appendix E.2 following this section.

3.5.5.2.2 Update master file - The update program would format the data as required for the Inspection and Maintenance Master File and merge the records onto that file. At this point it would also be possible to add the VIN number from the State Vehicle License System if necessary.

3.5.5.3 On-line error correction module

3.5.5.3.1 On-line correction program - This program, operating through CICS, would allow the on-line correction of errors as identified in the edit reports. This on-line subsystem would allow access to the rejected records in a random order and allow the correction of these records as the information became available to the clerk. It would also be possible to arrange these errors into batches to allow for appropriate controls of throughput by the clerical staff.

3.5.5.3.2 Select corrected records - This program would select records that had been corrected and released by the clerical staff and prepare them for input to the Master File Update Subsystem.

3.5.5.4 Report Module

This subsystem would consist of from three to five "sort and report" programs to allow for the periodic reporting of the statistics gathered by the Vehicle Inspection and

Maintenance System. Through parameters external to the programs, the same programs could be used for reports on a monthly, quarterly, annual, or on-demand basis. These reports would include:

- Reports ordered by year, make of automobile
- Reports ordered by year, make, station
- Special reports and extracts

APPENDIX 3.5-A

Edit Criteria

Data input from the Inspection and Maintenance data input forms should be reviewed by the edit program for reasonableness, data validity and data consistency.

- Reasonableness checks:
    - License number should be checked for conformance to one of the standard license number patterns (i.e., XX-NNN).
    - Station number should be numeric and greater than zero.
    - Inspector number should be numeric and greater than zero.
    - Model year should be numeric.
    - Number of cylinders should be numeric.
    - First test emission levels should be numeric and greater than zero.
    - Retest emission levels should be blank or numeric greater than zero.
    - Adjustment only station number should be blank or numeric greater than zero.
    - Adjustment only inspector number should be blank or numeric greater than zero.
- All data should be tested to the extent possible for validity:
    - Date of test should be of valid month, day, year.
    - Station number should be from the list of valid stations.
    - Model year shuld not be greater than the current year plus one.

- Visual inspection failed categories should be checked against make and model data to determine if those components were available as original equipment on that automobile.

- Certificate status of "compliance" the emission levels for either the first test or the second test should be within the minimum standards for emissions for that model year automobile.

- Consistency checks should be made to ensure that it is possible to have what otherwise appears to be reasonable or valid data such as:

  - The date of the inspection should be prior to the current date.

  - Cost amounts for repair should be equal to zero unless the first inspection test emission levels exceeded the emissions standards.

APPENDIX B

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The following are documents pertaining to statistical analyses and sampling techniques.

1. Memo from Rick Fawcett to Jerry Gallagher, 8/5/80
2. Memo from Elmer Remmenga to Jerry Gallagher, 8/27/80
3. Report by Elmer Remmenga, 10/9/80

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Department of Statistics

Colorado State University
Fort Collins, Colorado
80523

MEMORANDUM

August 27, 1980

TO: Jerry Gallagher, Industrial Sciences

FROM: Elmer Remmenga, Statistics

Survey costs are such that usually a small portion, a sample, of a population is studied. A cost analysis based on sample size must be balanced against the precision of the sample results. Samples are always uncertain because of the vagaries of sampling--randomness, chance, etc. Intuitively, and theoretically, large samples are more reliable; but also more expensive. The amount of uncertainty depends on the inherent variability in the population. This variability can be determined by theoretical concepts based on mathematical formulations of the distribution (normal, binomial).

As an illustration, consider the probability of heads from tossing a coin. The coin may be honest or biased. An infinite number of tosses exist and only after evaluating several million tosses can the probability of heads be stated precisely. Consider tossing the coin ten times, a sample of outcomes. If the coin is honest, five heads are expected, but four or six heads is not unusual and three or seven are not disturbing. However, at some point (1, 2, 8, 9 heads) the coin becomes suspect. It is known that 0 or 10 heads are possible in any given small sample and that the next small sample will give a different result with larger samples being more reliable; that is, we feel more secure, more confident, with the data from a large sample (100 tosses of the coin). Uncertainty is the name of sampling, thus a sampling strategy is needed.

This paper is a simple look at sampling strategies involving the normal approximation of the binomial, looking at a range of sample sizes, their theoretical precision, and their cost.

The normal distribution is the error model most widely used. Here it provides the multiplier 1.96 which is the upper and lower bound of the central 95 percent of the area under a normal curve. If a data set is adequately normal, then 95 percent of its area is bounded by the interval: the mean ±1.96 standard deviations.

The binomial distribution recognizes only two outcomes (heads or tails, pass or fail). When the sample size is large (over 30) and the distribution symmetrical, the discrete binomial can be approximated nicely by the normal and thus take advantage of the property involving the 95 percent interval. The standard deviation of the binomial is $\sqrt{pq/n}$ where p is the probability of success (pass or heads) and $q = 1-p$ is the probability of failure (fail or tails). As n becomes large, the standard deviation becomes small and thus the estimates more precise.

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A desirable result would be to be 95 percent sure with a narrow, but affordable, range of uncertainty.

The N-n/N-1 is called a finite population correction and is needed to compensate for large sampling proportions (when n/N is large, perhaps greater than .05) and that will be true here. The sampling involves a large portion of the population. When n/N is small, .01 or .001 (when N is large, 1,000,000 or more), then the correction approaches one and is ignored. Here, it has a real impact with N=100.

EER:lmp

SAMPLE SIZE AND SAMPLE PLAN CONSIDERATIONS FOR EVALUATING EMISSION TEST RECORDS FOR CONSUMER PROTECTION

Given 1.4 x 10^6 test records each year from 1200 stations at an average of 100 records per station per month (1200 x 12 x 100 = 1,440,000). Few test stations will have less than 20 tests per month but some may exceed 500. This range in volume should be considered.

The following suggested sample schemes are based on several assumptions: quality equipment everywhere, equally competent personnel, and random distribution of automobiles partially accomplished by make-model specifications for emission levels. Volume is still a problem.

Based on the 1979 report, a 35 percent decrease in HC can be detected with 80 to 100 records and a 35 percent decrease in CO can be detected with 20 to 25 records. This data is somewhat suspect, however, because it does not really parallel the proposed field testing program and apparently contains a variety of trained-untrained personnel. It is the only information readily available on ppm HC and percent CO.

These changes will occur only due to the 85 percent of cars that pass after repair of the 35 percent that fail on the first test, about 30 percent of the total. A small station handling only 40 tests per month will have only 12 records that apply. A 25 percent sample will get 36 records in the sample each year. The average station would have 90 records sampled per year.

Following an earlier suggestion, a sample of about 25 percent of the records (350,000) is proposed. This can be done in two stages.

I. Sample one half of the stations each month. The 50-50 split can be accomplished with a random number table or by simply assigning odd-even license numbers to odd-even months. I see no bias in sequence of application and/or assigning of station licenses. New stations can be added to the scheme with no problem. A new 50-50 split can be made each 2 months or the same split maintained. Each station will be sampled 6 times each year.

   Randomly, during a month it is sampled, each station will be evaluated in total to compare the sample with the entire operation of the station. This can be accomplished with a random number table, sampling without replacement. Approximately 100 stations will be evaluated each month.

II. Test records can be drawn from the sample stations each month by one of the following schemes.

   a. Simple random sample. Take one half (every other record) of the stations' records in sequence. The order of appearance for inspection ought not be biased, but there is likely to be an end-of-the-month rush and possible bias. This will result in a self weighting sample and will be easy to handle computationally. Reliable results will be obtained for the population but large stations will be over sampled and small stations under sampled and will have low precision. Sample size would be about .25 x 1.4 x 10^6 = 350,000.

b. Obtain a fixed number of observations from each station, say 50 per station, to correspond with a 50 percent sample of the average station and necessarily take all records for smaller operations. The sampling would be accomplished in sequence by taking every nth record from a file based on the monthly volume.

Equal precision would be obtained for every station, unless there is very low volume and then all data would be used and the precision would be whatever happens for that station. It would be necessary to use a different blow-up factor for each station to get total results for the population, but this is a simple computer problem.

Sample size would be approximately 1200 x 50 x 6 = 360,000.

With equal sample sizes, it would be very easy to obtain the probability that each station is out of compliance each sampled month for percent failed and change in HC and CO.

Optical scanner records leading to an overall 80 - 90 percent sample would be preferable for efficiency, economics, and statistics.

10/9/80
EER:lmp

COLORADO DEPARTMENT OF HEALTH
Division or Section of Data Services

INTER-OFFICE COMMUNICATION

TO : Jerry Gallagher
DATE : August 5, 1980
FROM: Rick Fawcett
SUBJECT: Auto Emission Sampling

This sampling strategy assumes the primary target population to be the auto testing station's monthly data, with a secondary target population being all testing station's yearly data. The calculations used in this report are based on the following figures:

Primary population $\approx$ 100
Secondary population = 1.4×10^6
Testing stations $\approx$ 1,166
$\bar{X}$ keystrokes/card $\approx$ 50
Cost/1000 strokes $\approx$ 1.25

The user is cautioned that changes in the assumed populations may alter the validity of this sampling strategy.

The primary target population may be sampled with a systematic sampling strategy. If the collected station data is in random order, the first (n) cards may be selected for each station. If the cards are ordered when received from the testing stations, the sample must be selected randomly. Random sampling may be achieved by numbering each card and selecting (n) cards by using a table of random numbers.

The strategy used to select the data cards should be checked for validity with a statistical comparison of the sample to the population. This check should be made at least once for each station.

The secondary target population may be sampled with a stratified time sample. The strata being geographical subsets of the state of Colorado, i.e., counties, planning regions, or any easily established boundary. This will insure, that on any given month, the sample will not be geographically biased. The sample time should be based on monthly intervals, so that for any given month a testing station will either be sampled or not. Therefore, the time sample selected must be a factor of 12.

For example, a 50% sample could be drawn from the secondary population by choosing 1/2 of the testing stations from each planning region for 6 months, and the other 1/2 of the testing stations for the other 6 months.

An alternating month system would reduce the chance of introducing a sampling bias caused by changes occurring during the year. It would also reduce the period that a given testing station is not checked for accuracy.

The sample sizes (n) for the primary and secondary target populations must be selected to produce an error figure that will be appropriate for the cost, both in effort and dollars, if a wrong decision is made from the sample statistics. Formulas and examples are provided which produce an error figure for a given size. This error factor can be used to determine the range in which the samples proportion will fall around the population proportion. The error figure is dependent on the sample size, and may be reduced by increasing the sample size.

Signature

AD BUS-29 (10-29-100)

Given the differences between the sizes of the primary and secondary target populations, the error figure for the secondary target population will always be less than for the primary target population. Therefore, an acceptable error figure at the primary level will also produce an acceptable error figure at the secondary level.

Given the cost/1000 keystrokes and the $\bar{X}$ strokes/card, the data entry costs may be estimated for different sample sizes.

N = population

n_1 = primary sample

n_2 = secondary sample

KS = X keystrokes per card

$$\frac{N\times KS\times n_1\times n_2}{1\times10^3}\times 1.25 = \text{cost}$$

Population

$$\frac{1.4\times10^6\times50}{1\times10^3}\times 1.25 = 87{,}500.00$$

$n_1=50\%$ $n_2=50\%$

$$\frac{(1.4\times10^6)\times50\times.5\times.5}{1\times10^3}\times 1.25 = 21{,}875.00$$

$n_1=30\%$ $n_2=50\%$

$$\frac{(1.4\times10^6)\times50\times.3\times.5}{1\times10^3}\times 1.25 = 13{,}125.00$$

The following sampling statistics were prepared by Bruce Ellis, Statistical Analyst for Health Services.

To: Jerry Gallagher
From: Rick Fawcett

Date: August 5, 1980
Subject: Auto Emission Sampling

Using a total population size of 100 (N) from a target population defined as the number of auto emission inspections of any given solution and of which a proportion (P) represents passed inspections, an error term (e) can be calculated for any given sample size (n) and acceptable confidence level (α) such that P can be expected to differ from the sample proportion (p) by no more than 'e' with 100 $(1-\alpha)$ % confidence. 'e' is calculated as the product of the standard error of p and the 'z' value appropriate to the selected α (in this case, $\alpha/2$, applying a two-tailed z distribution):

$$e = z_{\alpha/2}\sqrt{\frac{P(1-P)}{n}\left(\frac{N-n}{N-1}\right)}$$

The sample proportion p may be substituted for P, however, since p is also unknown at this point a value of 0.25 can be used for the quantity $[P(1-P)]$, since this is it's maximum value for all values of P between zero and 1.00. Consequently, the derived e represents an upper bound also. This formula also employs the correction factor $\frac{(N-n)}{(N-1)}$ for a finite population, assumed to be roughly 100 for any tested inspection station. The α level was set at 0.05 (95% confidence), for which a z value of 1.96 (two-tailed) was identified.

For n=10, e =

$$1.96\sqrt{\frac{0.25}{10}\left(\frac{100-10}{100-1}\right)} = 1.96\sqrt{(.0250)(.9091)} = .2953$$

For n=20, e =

$$1.96\sqrt{\frac{0.25}{20}\left(\frac{100-20}{100-1}\right)} = 1.96\sqrt{(.0125)(.8081)} = .1970$$

For n=30, e =

$$1.96\sqrt{\frac{0.25}{30}\left(\frac{100-30}{100-1}\right)} = 1.96\sqrt{(.0083)(.7071)} = .1506$$

For n=40, e =

$$1.96\sqrt{\frac{0.25}{0}\left(\frac{100-40}{100-1}\right)} = 1.96\sqrt{(.0063)(.6061)} = .1208$$

To: Jerry Gallagher
From: Rick Fawcett

Date: August 5, 1980
Subject: Auto Emission Sampling

For n=50, e =

$$1.96 \sqrt{\frac{0.25}{50}\left(\frac{100-50}{100-1}\right)} = 1.96\sqrt{(.0050)(.5051)} = .0480$$

These error terms represent an upper bound for all values of P. If P equals 0.65, e can be calculated for sample sizes 10, 30 and 50 at .2820, .1440 and .940, respectively. Nonetheless, 95% of samples of size 10, drawn from a population of 100 with P=.65, can be expected to derive sample proportions ranging from (P-e) to (P+e), or fron .3680 to .9320. Consequently, a sample size of less than 30 for a target population defined as the vehicles inspected by a given station in a given month seems inadvised.

Should the target population be defined to include all vehicles inspected by a given station throughout the year, the expected error can be calculated (for an estimated of 12 x 100 or 1200) for a combined sampling taken every-other month:

For n=60 (10 per month for 6 months), e =

$$1.96\sqrt{\frac{0.25}{60}\left(\frac{1200-60}{1200-1}\right)} = 1.96\sqrt{(.0042)(.9508)} = .1240$$

For n=120 (20 per month for 6 months), e =

$$1.96\sqrt{\frac{0.25}{120}\left(\frac{1200-120}{1200-1}\right)} = 1.96\sqrt{(.0021)(.9008)} = .0854$$

For n=180 (30 per month for 6 months), e =

$$1.96\sqrt{\frac{0.25}{180}\left(\frac{1200-180}{1200-1}\right)} \quad 1.96\sqrt{(.0014)(.8507)} = .0679$$

For n=240 (40 per month for 6 months), e =

$$1.96\sqrt{\frac{0.25}{240}\left(\frac{1200-240}{1200-1}\right)} \quad 1.96\sqrt{(.0010)(.8007)} = .0554$$

To: Jerry Gallagher
From: Rick Fawcett

Date: August 5, 1980
Subject: Auto Emission Sampling

Again, these errors represent upper bounds and may be lower for known values of P. The critical issue with defining the target population in this manner, however, is whether the sampling approach is viable, and whether the month and day of the inspection represents a systematic bias.

Note: This uses a normal approximation to the binomial distribution. This is appropriate for sample sizes of around 15 or more if P lies between 0.35 and o.65, but may be an inadequate approximation for smaller samples.

Source:

Walpose, R.E. Probability and Statistics for Engineers and Scientists, 1972 pp 201-205

Ferguson, G. A. Statistical Analysis in Psychology and Education, 1971 pp 135-143

APPENDIX C

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The following text is the section of the Vehicle Emissions Control Study Guide - AIR Program (January, 1982) which explains the use of the vehicle inspection forms. The inspection form discussed is the green form put in use in January 1982.

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VEHICLE INSPECTION FORM

General Instructions

The following pages contain samples of the step-by-step procedure for using and filling out the emissions inspection form. A typical vehicle is used for the example and hypothetical vehicle data is presented. For actual inspections the vehicle data should be taken from the vehicle registration. Actual station and emission mechanic numbers should always be used. The format used in this presentation may be different from what is used in real emissions testing. However if the general procedures used in filling out the form are understood, no difficulty should be experienced in using a similar form of this type.

Each form consists of a top sheet and two copies. In addition, the lower half of copy #3 is the owner's notification of failure to pass the initial inspection. The top half of copy #3 is the emissions certificate and should be given to the owner when the inspection or inspection/readjustment process is completed.

Only a number 2 (No. 2) lead pencil may be used in filling out the vehicle inspection form. Write on a hard surface (clipboard, tabletop, etc.) and bear down firmly so the recorded information can be read on all copies. Use care so that the form is not soiled, folded, torn, punctured or mutilated. The top (#1 copy) will be optically scanned by a computer reader. An agent from the Colorado Department of Revenue will collect the top (#1 copy) periodically.

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Once the inspection form is initiated, the official inspection process has begun and that form cannot be crossed out, erased, or used for any other vehicle. Inspection forms may be obtained from the Colorado Department of Revenue and available to only licensed AIR emission testing stations.

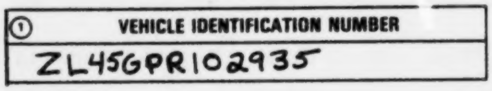
VEHICLE INSPECTION FORMS

I. FIRST TEST INFORMATION

The following instructions show how to complete sections of the form for vehicles being tested for the first time. Information requested in blocks #1-9 must be accurately recorded on the form for all vehicles being inspected. Blocks #10, 11, 16 and 17 must be completed for all vehicles that pass the first inspection.

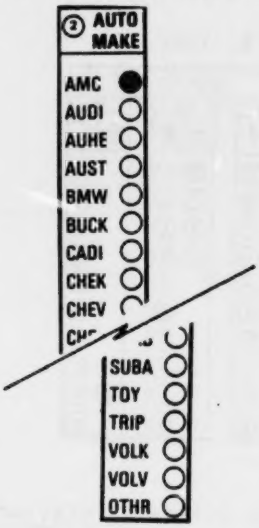
A. Obtain the vehicle identification number (VIN) from the registration. Compare with the VIN on actual vehicle (numbers must agree) and write this number in block #1, "VEHICLE IDENTIFICATION NUMBER."

Example: ZL45GPR102935.

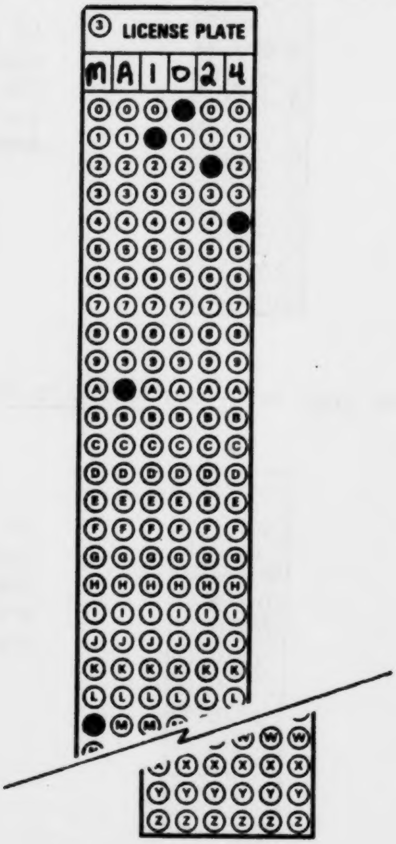


① VEHICLE IDENTIFICATION NUMBER
ZL45GPR102935

B. Code the vehicle make in block #2. Example: AMC


② AUTO MAKE
AMC ●
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

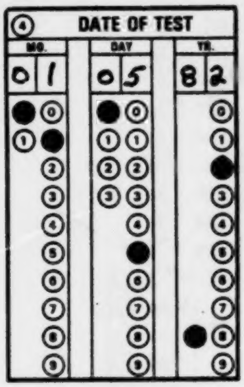
C. Write in and code the actual vehicle license (metal) plate number (plate and registration must agree) in block #3. Example: MA1024


③ LICENSE PLATE
M A 1 0 2 4

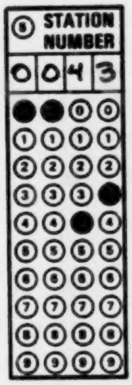
If the number has less than six digits, shift the number to the right and code zeros in the empty spaces to the left.

Temporary, paper license plate numbers are not to be recorded.

D. Write in and code the date that the inspection form is started in block #4. Example: January 5, 1982

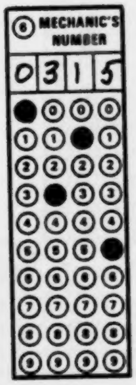

④ DATE OF TEST
MO.
DAY
YR.
0 1
0 5
8 2

E. Write in and code the emissions station license number in block #5. Example: 0043


⑤ STATION NUMBER
0 0 4 3

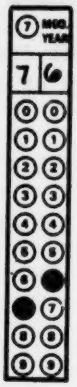
If the number has less than four ditits, shift the number to the right and code zeros in the empty spaces to the left.

F. Write in and code your emissions mechanic license number in block #6. Example: 0315

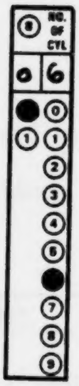

⑥ MECHANIC'S NUMBER
0 3 1 5

If the number has less than four digits, shift the number to the right and code zeros in the empty spaces to the left.

G. Write in and code the last two digits of the vehicle year of manufacture in block #7. Example: 1976

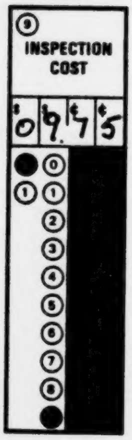

7
MFG. YEAR
7
6

H. Write in and code the number of engine cylinders in block #8. Example: 1976 AMC, 6 cylinders


8
NO. OF CYL
0
6

NOTE: Rotary engine vehicles should be coded as to the number of rotors.

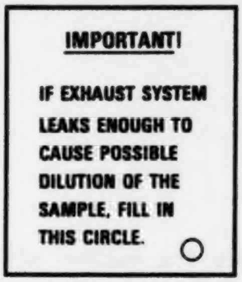
I. Write in the inspection cost in block #9. Code the circles under the dollar portion only.


9
INSPECTION COST
$
$
¢
¢
0
9
7
5

NOTE: Maximum inspection cost is ten dollars.

Having accurately completed all required information in blocks #1-9, you are now ready to perform the actual emissions inspection.

Important: Check the exhaust system for excessive leaks and code the form as required.



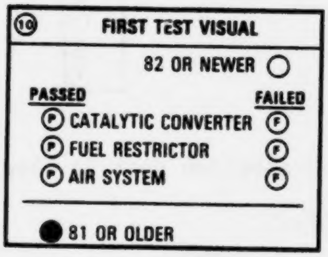
IMPORTANT!

IF EXHAUST SYSTEM LEAKS ENOUGH TO CAUSE POSSIBLE DILUTION OF THE SAMPLE, FILL IN THIS CIRCLE. ○

NOTE: If excessive leaks are found, proceed with the inspection.

II. IDLE TESTS

A. Code the appropriate circle in block #10. Visual inspections are to be done on ONLY 1982 and newer vehicles. Code "81 or older" if applicable.



⑩ **FIRST TEST VISUAL**

82 OR NEWER ○

PASSED **FAILED**

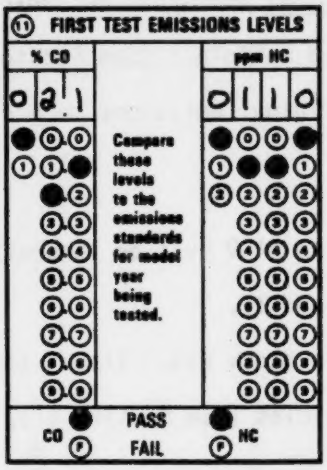
Ⓟ **CATALYTIC CONVERTER** Ⓕ

Ⓟ **FUEL RESTRICTOR** Ⓕ

Ⓟ **AIR SYSTEM** Ⓕ

● **81 OR OLDER**

B. Following approved procedures, obtain the idle CO and HC readings. Compare with the maximum allowable emissions standards schedule for CO and HC; write in and code the actual idle CO and HC readings in block #11, "FIRST TEST EMISSIONS LEVELS." Example: 2.1% CO and 110 ppm HC.



⑪ **FIRST TEST EMISSIONS LEVELS**

% CO: 0 2 . 1

ppm HC: 0 1 1 0

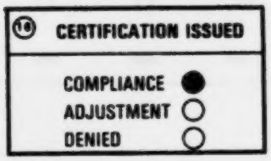
Compare these levels to the emissions standards for model year being tested.

CO ● **PASS** ● **HC**
Ⓕ **FAIL** Ⓕ

EMISSIONS STANDARDS

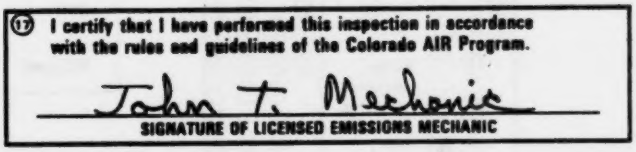
VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

C. If CO and HC readings are equal to or less than the applicable standards, code "COMPLIANCE" in block #16; record the sticker/certificate number, and sign the inspection form in block #17.



⑯ **CERTIFICATION ISSUED**

COMPLIANCE ●
ADJUSTMENT ○
DENIED ○



⑰ **I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.**

John T. Mechanic

SIGNATURE OF LICENSED EMISSIONS MECHANIC

The emission inspection is now completed. Forms can be separated and distributed.

III. VEHICLES WHICH FAIL THE FIRST TEST

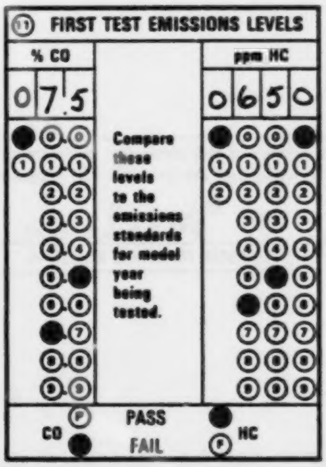
The following instructions show how to complete sections of the inspection form for vehicles which fail the first test with CO, HC, or both emissions levels greater than applicable standards. At this time, the vehicle owner has authorized the original emissions mechanic to make corrective readjustments to the failed vehicle. (See Sections IV and V for adjustments made by other than the original emissions mechanic.)

REVIEW

A. Information requested in blocks #1-9 must be accurately completed and coded as described in Sections I and II.

B. Code the appropriate circle in block #10. Visual inspections are to be done on ONLY 1982 and newer vehicles (See Section VI). Code "81 or older" if applicable.

C. Following approved procedures, obtain the idle CO and HC readings; compare with the allowable limits schedule for CO and HC readings; write in and code the actual idle CO and HC readings in block #11, "FIRST TEST EMISSIONS LEVELS." Example: 1976 vehicle, 7.5% CO and 650 ppm HC.

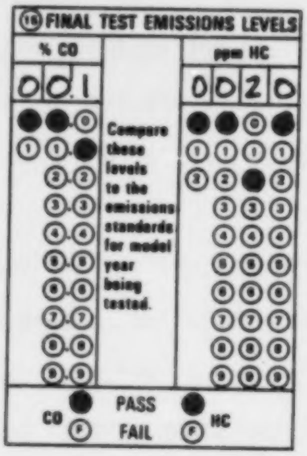

⑪ FIRST TEST EMISSIONS LEVELS
% CO
ppm HC
0 7 5
0 6 5 0
Compare these levels to the emissions standards for model year being tested.
CO
PASS
FAIL
HC

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

If the CO, HC, or both readings are above applicable standards, notify the owner that the vehicle has failed the first test.

D. In many cases you will be requested to make the required five parameter adjustments (Chapter C, Study Guide) and complete the inspection. After doing the adjustments, retest the vehicle to obtain another set of final emissions readings. Write in and code the information in block #15, "FINAL TEST EMISSIONS LEVELS." Example: 0.1% CO and 20 ppm HC.

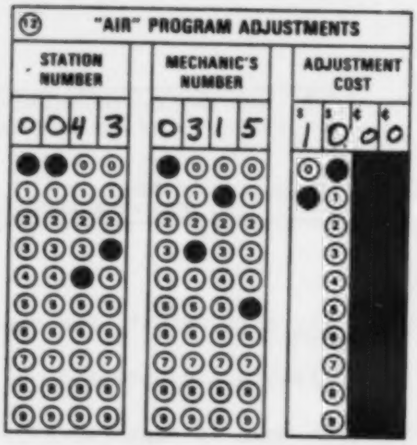


⑮ FINAL TEST EMISSIONS LEVELS

% CO		ppm HC
0 0.1	Compare these levels to the emissions standards for model year being tested.	0 0 2 0

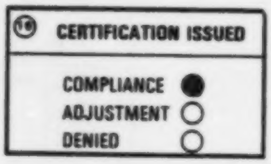
CO ● PASS ● HC
CO Ⓕ FAIL Ⓕ HC

E. If the final emissions levels are equal to or below the applicable standards; code "COMPLIANCE" in block #16. If either CO, HC or both are above the standards, code "ADJUSTMENT." Write in and code the station license number, your mechanic license number and the adjustment costs ($15 maximum). Code only the dollar portion in block #12. Sign the form in block #17.



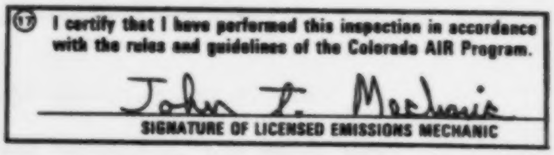
⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER	MECHANIC'S NUMBER	ADJUSTMENT COST
0 0 4 3	0 3 1 5	$ 1 0 ¢ 0 0



⑯ CERTIFICATION ISSUED

COMPLIANCE ●
ADJUSTMENT ○
DENIED ○



⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

John T. Mechanic

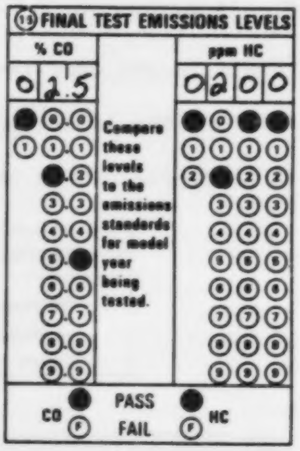
SIGNATURE OF LICENSED EMISSIONS MECHANIC

The emissions inspection is now complete. Forms can be separated.

IV. VEHICLES THAT HAVE FAILED THE FIRST TEST AND ARE READJUSTED BY OTHER THAN THE ORIGINAL EMISSIONS MECHANIC

In some cases, the vehicle owner may choose to take the failed vehicle and attempt to repair or adjust it himself, or perhaps to a non-licensed mechanic. If the owner chooses to do this, separate the lower half of page #3 (do not separate the form pages) and give it to him/her explaining that he/she has up to ten days (from the date of the first test) to return for one free reinspection at your station.

A. When the owner returns, retest the vehicle to obtain another set of emissions readings and compare with applicable standards. If the vehicle passes, write in and code these readings in block #15, "FINAL TEST EMISSIONS LEVELS" and code "COMPLIANCE" in block #16. Sign the form in block #17.



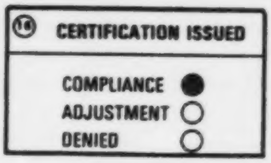
⑮ FINAL TEST EMISSIONS LEVELS

% CO: 0 2.5

ppm HC: 0200

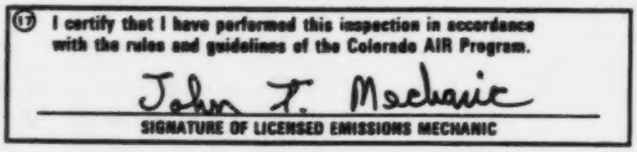
Compare these levels to the emissions standards for model year being tested.

CO ● PASS ● HC
Ⓕ FAIL Ⓕ



⑯ CERTIFICATION ISSUED

COMPLIANCE ●
ADJUSTMENT ○
DENIED ○



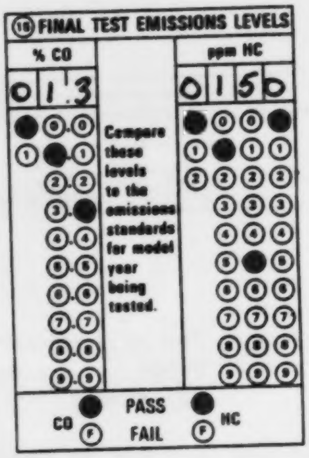
⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

John T. Mechanic

SIGNATURE OF LICENSED EMISSIONS MECHANIC

B. If the returned vehicle fails this retest, the owner may now allow you to perform the five parameter adjustments. If the owner wishes to remove the vehicle to have it repaired/adjusted elsewhere, he may do so. If the owner authorizes you to perform the adjustments, make the necessary adjustments.

1. If the vehicle now passes, write in and code these final readings in block #15, "FINAL TEST EMISSIONS LEVELS," and code "COMPLIANCE" in block #16.



⑮ FINAL TEST EMISSIONS LEVELS

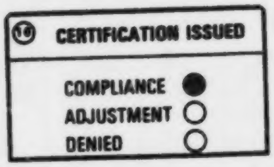
% CO: 01.3

ppm HC: 0150

Compare these levels to the emissions standards for model year being tested.

CO PASS ● FAIL Ⓕ

HC PASS ● FAIL Ⓕ



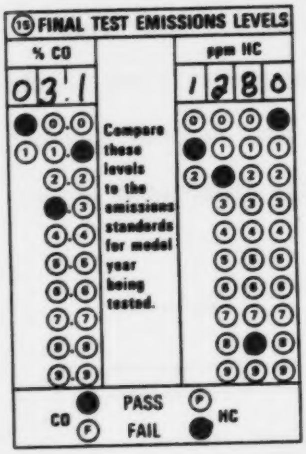
⑯ CERTIFICATION ISSUED

COMPLIANCE ●

ADJUSTMENT ○

DENIED ○

2. If the vehicle fails after your readjustment, write in and code these final readings in block #15 and code "ADJUSTMENT" in block #16.



⑮ FINAL TEST EMISSIONS LEVELS

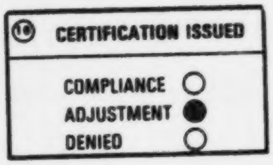
% CO: 03.1

ppm HC: 1280

Compare these levels to the emissions standards for model year being tested.

CO PASS ● FAIL Ⓕ

HC PASS Ⓟ FAIL ●



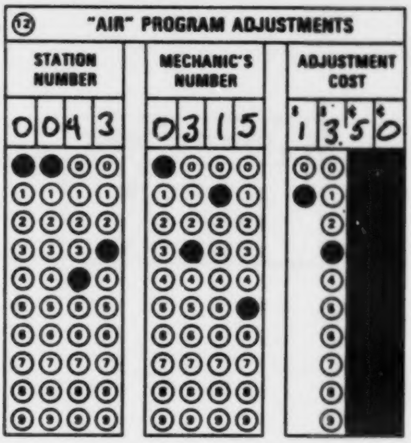
⑯ CERTIFICATION ISSUED

COMPLIANCE ○

ADJUSTMENT ●

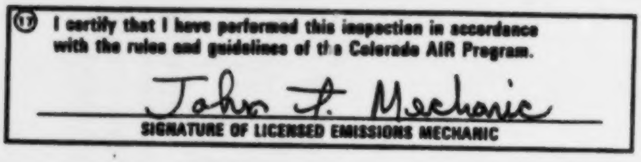
DENIED ○

C. Write in and code the station license number and your mechanic license number. Write in the adjustment costs but code only the whole dollar amount in block #12. Sign the form in block #17.



⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER				MECHANIC'S NUMBER				ADJUSTMENT COST			
								$	$	¢	¢
0	0	4	3	0	3	1	5	1	3.	5	0
●	●	⓪	⓪	●	⓪	⓪	⓪	⓪	⓪		
①	①	①	①	①	①	●	①	●	①		
②	②	②	②	②	②	②	②		②		
③	③	③	●	③	●	③	③		●		
④	④	●	④	④	④	④	④		④		
⑤	⑤	⑤	⑤	⑤	⑤	⑤	●		⑤		
⑥	⑥	⑥	⑥	⑥	⑥	⑥	⑥		⑥		
⑦	⑦	⑦	⑦	⑦	⑦	⑦	⑦		⑦		
⑧	⑧	⑧	⑧	⑧	⑧	⑧	⑧		⑧		
⑨	⑨	⑨	⑨	⑨	⑨	⑨	⑨		⑨		



⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

John T. Mechanic

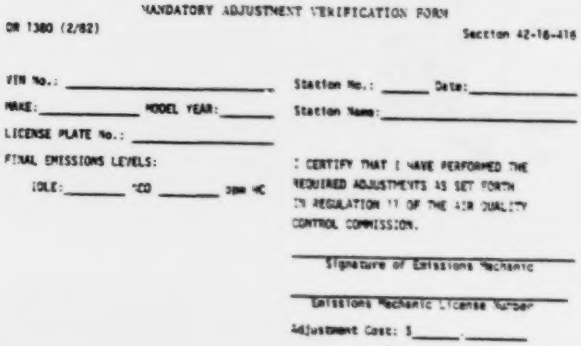
SIGNATURE OF LICENSED EMISSIONS MECHANIC

The maximum AIR Program cost for adjustments is $15.

The emissions inspection is now completed. The form may be separated.

V. ADJUSTMENTS BY ANOTHER LICENSED EMISSION MECHANIC

Some vehicles may be adjusted by another licensed emissions mechanic outside your shop. Such information will appear on an "adjustment verification" form (below) attached to the lower half, page 3 of the original inspection form when the owner returns. This information (station and emissions mechanic license numbers, and retest CO and HC emissions readings) must be transferred (written and coded) to pages 1 and 2 of the inspection form.



MANDATORY ADJUSTMENT VERIFICATION FORM

DR 1380 (2/82)

Section 42-16-416

VIN No.: ____________________

Station No.: ______ Date: __________

MAKE: __________ MODEL YEAR: ______

Station Name: ____________________

LICENSE PLATE No.: ______________

FINAL EMISSIONS LEVELS:

IDLE: ______ %CO ______ ppm HC

I CERTIFY THAT I HAVE PERFORMED THE REQUIRED ADJUSTMENTS AS SET FORTH IN REGULATION 11 OF THE AIR QUALITY CONTROL COMMISSION.

____
Signature of Emissions Mechanic

____
Emissions Mechanic License Number

Adjustment Cost: $______.______

Roles may be reversed and you could be asked to readjust a vehicle that has failed elsewhere. You must be sure to write in and code your station license and emission mechanic license number as well as the final CO and HC emissions reading on the adjustment verification form.

VI. VISUAL INSPECTIONS: 1982 AND NEWER VEHICLES

All 1982 and newer vehicles are required to have a visual inspection of certain specific emissions control equipment as originally installed by the manufacturer. From the underhood emissions control label or decal, determine the type of emission control equipment installed on the vehicle being inspected, specifically:

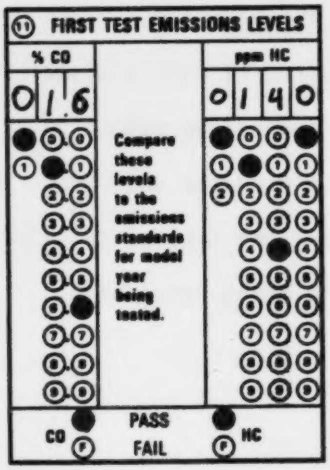
- Air pump or air aspirator system
- Catalytic converter(s)
- Unleaded fuel required

If no decal or sticker is present or this specific information is not available on the decal/sticker, consult an appropriate shop or emissions control manual.

Visually inspect the vehicle for the following equipment if originally equipped:

- Air pump or air aspirator system
- Catalytic converter(s)
- Fuel filter inlet restrictor

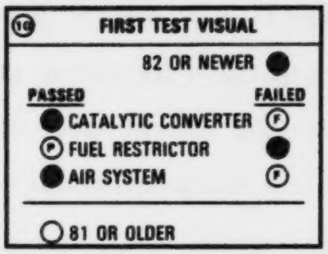
All parts of the above system are to be installed and intact. Only a visual inspection is to be done, no functional or performance tests are to be performed. If missing or damaged equipment/parts are observed during the first inspection, code block #10 accordingly and proceed with the inspection. You should take First Test Emissions Levels for CO and HC and record in block #11. You may not issue an emissions compliance or adjustment certificate if the vehicle fails this visual inspection.



⑪ **FIRST TEST EMISSIONS LEVELS**

% CO		ppm HC
01.6	Compare these levels to the emissions standards for model year being tested.	0140

CO ● PASS ● HC
CO Ⓕ FAIL Ⓕ HC



⑩ **FIRST TEST VISUAL**

82 OR NEWER ●

PASSED		FAILED
●	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	●
●	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

VII. VEHICLE REPAIRS

Although encouraged, repairs beyond the required five parameter adjustments are NOT REQUIRED.

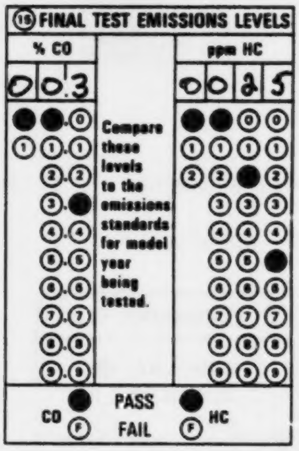
Note:

As of July 1, 1982, all 1981 and newer vehicles that fail after adjustments are performed are required to spend up to a maximum of $100 of emissions related repairs to lower tailpipe emissions. Repairs need only be performed until the vehicle is in compliance with the standards or the $100 maximum has been spent; whichever comes first. This excludes any required repairs as a result of failing the Visual Inspection ('82 and newer).

Repairs to and/or replacement of items covered in the visual inspection must be completed before any final adjustments can be performed. For 1982 and newer vehicles, these items include:

- Air pump or air aspirator system
- Fuel filter inlet restrictor
- Catalytic converter(s)

After repairs and/or adjustments have been made, a final set of CO and HC readings should be made. Write in and code these readings in block #15. Example: 0.3% CO and 25 ppm HC.



⑮ FINAL TEST EMISSIONS LEVELS

% CO

0 0.3

ppm HC

0 0 2 5

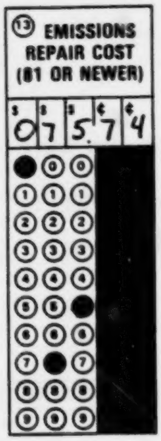
Compare these levels to the emissions standards for model year being tested.

CO ● PASS ● HC

Ⓕ FAIL Ⓕ

Write in the parts and labor costs (for the repairs which were performed on the vehicle) in block #13. Code only the dollar portion.

Example: Parts = $51.22
Labor = 24.52
Total $75.74

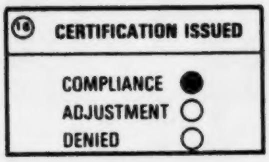


⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$	$	$	¢	¢
0	7	5.	7	4
●	⓪	⓪		
①	①	①		
②	②	②		
③	③	③		
④	④	④		
⑤	⑤	●		
⑥	⑥	⑥		
⑦	●	⑦		
⑧	⑧	⑧		
⑨	⑨	⑨		

Note: The "Repair Cost" (maximum $100) does not include the inspection or adjustment fees.

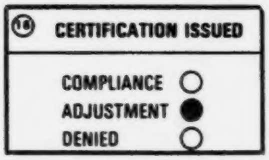
If the CO and HC readings are equal to or below applicable standards, code "COMPLIANCE" on block #16.



⑯ CERTIFICATION ISSUED

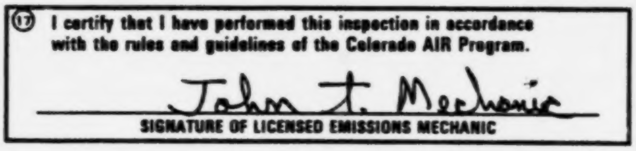
COMPLIANCE ●
ADJUSTMENT ○
DENIED ○

If the readings are still above standards after appropriate repairs and/or adjustments, code "ADJUSTMENT" in block #16 and sign the form in block #17.



⑯ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ●
DENIED ○



⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

John T. Mechanic

SIGNATURE OF LICENSED EMISSIONS MECHANIC

VIII. INSPECTION FORM DISTRIBUTION

After the vehicle inspection form has been completed or more than ten days have elapsed since the first inspection, the inspection form document is to be separated and distributed as follows:

PAGE #1 - Hold for pick-up by the Department of Revenue investigator. DO NOT fold, staple, mutilate, soil or otherwise damage this section.

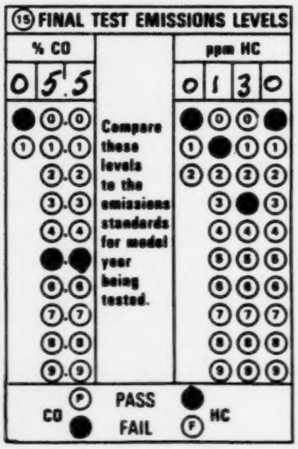
PAGE #2 - Retained by the licensed emission testing station for purposes of record keeping.

PAGE #3 - Vehicle owner's copy.

IX. EMISSION CERTIFICATE: "DENIED"

If a failed vehicle is not returned for a retest within ten days of the initial inspection, code block #16 "DENIED."

If the vehicle owner refuses to allow a licensed AIR Program emissions mechanic to perform corrective readjustments and/or the '81 and newer repairs to a vehicle that fails the retest, code block #16 "DENIED."



⑮ FINAL TEST EMISSIONS LEVELS

% CO		ppm HC
0 5.5	Compare these levels to the emissions standards for model year being tested.	0 1 3 0

CO Ⓟ PASS ● HC

CO ● FAIL Ⓕ HC

○ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ●

X. FREE REINSPECTION

Each emissions testing station must provide ONE FREE REINSPECTION upon request for each vehicle originally tested and failed either for visual or tailpipe test. This obligation extends for a period of ten days following the initial inspection.

APPENDIX D

The following documents are slightly reduced copies of three types of inspection forms. The first is the "blue form" in use for inspections from July 1, 1981 through December 31, 1982. The second is the "green form" in use for inspections conducted after December 31, 1981. The third is the newest type of form and will be used beginning July 1, 1982. For a discussion of differences between the first two types of forms, consult section 3.1. The actual forms are 8½" x 12" with a 5/8" strip at the top to hold the three pages and two carbon sheets together. Page one is white with colored ink. Page two is light blue with colored ink, page three is yellow with colored ink. Pages two and three are of lighter weight paper than the "Trans-Optic"® bond of page one. The instructions (page four) are printed on the reverse of page three. Alternate columns are shaded on all forms.

Preceding page blank

BLUE FORM

July - December, 1981

Preceding page blank

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE

- AMC ○
- AUDI ○
- AUHE ○
- AUST ○
- BMW ○
- BUCK ○
- CADI ○
- CHEK ○
- CHEV ○
- CHRY ○
- DATS ○
- DODG ○
- FIAT ○
- FORD ○
- HOND ○
- INTE ○
- JAGU ○
- JEEP ○
- LANC ○
- LINC ○
- MAZD ○
- MEBZ ○
- MERC ○
- MG ○
- OLDS ○
- OPEL ○
- PLYM ○
- PONT ○
- PORS ○
- PUGT ○
- RENA ○
- SAAB ○
- SUBA ○
- TOY ○
- TRIP ○
- VOLK ○
- VOLV ○
- OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO — DAY — YR

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MOD YEAR

⑧ NO OF CYL

⑰ CERTIFICATION ISSUED

- COMPLIANCE ○
- ADJUSTMENT ○
- DENIED ○

⑫ RETEST EMISSIONS LEVELS

% CO — ppm HC

Compare these levels to the emissions standards for model year being tested.

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

⑯ COSTS (IN DOLLARS)

INSP — ADJ. — REQUIRED REPAIR: LABOR — PARTS

⑪ RETEST

VISUAL INSPECTION

FAILED

- CATALYTIC CONVERTER ○
- FUEL RESTRICTOR ○
- AIR SYSTEM ○
- EXHAUST
- SYSTEM INTEGRITY ○

⑱ I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

⑨ FIRST TEST

VISUAL INSPECTION

FAILED

- CATALYTIC CONVERTER ○
- FUEL RESTRICTOR ○
- AIR SYSTEM ○
- EXHAUST
- SYSTEM INTEGRITY ○

⑩ FIRST TEST EMISSIONS LEVELS

% CO — ppm HC

Compare these levels to the emissions standards for model year being tested.

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

⑮ VOLUNTARY REPAIR

- TUNE UP ○
- CARBURETOR ○
- AIR CLEANER ○
- CHOKE ○
- OTHER (specify) ○

⑭ ADJUSTMENT ONLY

STATION NUMBER — MECHANIC NUMBER

⑬ HOME ADJUST

% CO — ppm HC

- PASS ○
- FAIL ○

EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

USE A NUMBER 2 PENCIL ONLY ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO DEPARTMENT OF HEALTH

PAGE 1

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

② AUTO MAKE

AMC ○
AUDI ○
AUNE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

☐☐☐☐☐☐

(six columns, each) ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ Ⓕ Ⓖ Ⓗ Ⓘ Ⓙ Ⓚ Ⓛ Ⓜ Ⓝ Ⓞ Ⓟ Ⓠ Ⓡ Ⓢ Ⓣ Ⓤ Ⓥ Ⓦ Ⓧ Ⓨ Ⓩ

④ DATE OF TEST

MO		DAY		YR	
☐	☐	☐	☐	☐	☐
⓪ ①	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⑧	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑤ STATION NUMBER

☐☐☐☐

(four columns, each) ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑥ MECHANIC'S NUMBER

☐☐☐☐

(four columns, each) ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑦ MOD. YEAR

☐☐

(two columns, each) ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑧ NO. CYL.

☐☐

⓪ ① | ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑰ CERTIFICATION ISSUED

COMPLIANCE ○ **COC**
ADJUSTMENT ○ **COA**
DENIED ○ **CD**

RETEST EMISSIONS LEVELS

% CO				ppm HC				DATE OF TEST (YR)
☐	☐ . ☐			☐	☐	☐	☐	
⓪ ①	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ . ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	Compare these levels to the emissions standards for model year being tested		⓪ ① ②	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	81 82 83 84 85 86

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

COSTS (IN DOLLARS)

INSP.		ADJ.		REQUIRED REPAIR					
				LABOR			PARTS		
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
⓪ ①	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ①	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

⑪ RETEST

VISUAL INSPECTION

FAILED

CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

FIRST TEST

VISUAL INSPECTION

FAILED

CATALYTIC CONVERTER ○
FUEL RESTRICTOR ○
AIR SYSTEM ○
EXHAUST
SYSTEM INTEGRITY ○

FIRST TEST EMISSIONS LEVELS

% CO			ppm HC			
☐	☐ . ☐		☐	☐	☐	☐
⓪ ①	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ . ⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	Compare these levels to the emissions standards for model year being tested	⓪ ① ②	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

VOLUNTARY REPAIR

TUNE-UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER ○
(specify)

HOME ADJUST

% CO		ppm HC			
☐	☐ . ☐	☐	☐	☐	☐

PASS ○

FAIL ○

ADJUSTMENT ONLY

STATION NUMBER				MECHANIC NUMBER			
☐	☐	☐	☐	☐	☐	☐	☐
⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1968-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

THIS COPY TO BE FILED AT AIR PROGRAM STATION

COLORADO DEPARTMENT OF HEALTH

"AIR" PROGRAM INSPECTION/READJUSTMENT REPORT

① VEHICLE IDENTIFICATION NUMBER

124693

② AUTO MAKE	③ LICENSE PLATE	④ DATE OF TEST MO / DAY / YR	⑤ STATION NUMBER	⑥ MECHANIC'S NUMBER	⑦ MOD. YEAR	⑧ NO OF CYL
	☐☐☐☐☐☐	☐☐ ☐☐ ☐☐	☐☐☐☐	☐☐☐☐	☐☐	☐☐

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

CERTIFICATION ISSUED

COMPLIANCE ○ COC
ADJUSTMENT ○ COA
DENIED ○ CD

IMPORTANT INFORMATION TO VEHICLE OWNERS

1. You must keep both halves of this form to present to a safety inspector at the time of vehicle safety inspection.
2. You must have both halves of this form to transfer to the new owner should you sell this vehicle.
3. YOU MUST HAVE A CERTIFICATION OF EMISSIONS CONTROL BEFORE YOU SELL THIS VEHICLE.
4. KEEP THIS CERTIFICATION WITH YOUR REGISTRATION.

PLEASE READ WARNING BELOW:

COSTS (IN DOLLARS)

INSP	ADJ	REQUIRED REPAIR LABOR	REQUIRED REPAIR PARTS
☐☐	☐☐	☐☐☐	☐☐☐

⑪ RETEST

VISUAL INSPECTION

	FAILED
CATALYTIC CONVERTER	○
FUEL RESTRICTOR	○
AIR SYSTEM	○
EXHAUST SYSTEM INTEGRITY	○

RETEST EMISSIONS LEVELS

% CO			Compare these levels to the emissions standards for model year being tested	ppm HC				DATE OF TEST (YR)
⓪	⓪	⓪		⓪	⓪	⓪	⓪	81
①	①	①		①	①	①	①	82
	②	②		②	②	②	②	83
	③	③			③	③	③	84
	④	④			④	④	④	85
	⑤	⑤			⑤	⑤	⑤	86
	⑥	⑥			⑥	⑥	⑥	
	⑦	⑦			⑦	⑦	⑦	
	⑧	⑧			⑧	⑧	⑧	
	⑨	⑨			⑨	⑨	⑨	

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

WARNING:

If the retest visual inspection portion of this form (box 11) indicates that this vehicle is missing any emissions control equipment, you may be required to have this equipment installed before you receive your next emissions inspection and/or safety inspection. Please contact a licensed emissions mechanic or the Department of Health for specific information.

I certify that I have performed this inspection and any required adjustments in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSION MECHANIC

124693

NOTE TO VEHICLE OWNER

1. You may make any adjustments or repairs yourself or have anyone else do them but your vehicle must meet the emissions standards or be adjusted by a licensed emissions mechanic before a Certification of Emissions Control can be issued.
2. If the exhaust integrity portion of the visual inspection (box 9) is checked, the exhaust system must be repaired before a valid emissions measurement can be obtained.

⑨ FIRST TEST

VISUAL INSPECTION

	FAILED
CATALYTIC CONVERTER	○
FUEL RESTRICTOR	○
AIR SYSTEM	○
EXHAUST SYSTEM INTEGRITY	○

⑩ FIRST TEST EMISSIONS LEVELS

% CO			Compare these levels to the emissions standards for model year being tested	ppm HC			
⓪	⓪	⓪		⓪	⓪	⓪	⓪
①	①	①		①	①	①	①
	②	②		②	②	②	②
	③	③			③	③	③
	④	④			④	④	④
	⑤	⑤			⑤	⑤	⑤
	⑥	⑥			⑥	⑥	⑥
	⑦	⑦			⑦	⑦	⑦
	⑧	⑧			⑧	⑧	⑧
	⑨	⑨			⑨	⑨	⑨

Ⓟ PASS Ⓟ
Ⓕ FAIL Ⓕ

VOLUNTARY REPAIR

TUNE UP ○
CARBURETOR ○
AIR CLEANER ○
CHOKE ○
OTHER (specify) ○

ADJUSTMENT ONLY

STATION NUMBER	MECHANIC NUMBER
☐☐☐☐	☐☐☐☐

HOME ADJUST (see Note to Vehicle Owner)

% CO	ppm HC
☐☐☐	☐☐☐☐

PASS ○
FAIL ○

EMISSIONS STANDARDS

VEHICLE YEAR	CO	HC
1969-71	7.0%	1200ppm
1972-74	6.0%	1200ppm
1975-76	5.5%	800ppm
1977-78	3.5%	500ppm
1979 & LATER	2.0%	400ppm

IMPORTANT – KEEP THIS FORM

It will allow you to have one free reinspection at the original inspection station within ten days if your vehicle fails its first inspection.

FOR ANY ADDITIONAL INFORMATION CONTACT

COLORADO DEPARTMENT OF HEALTH

Denver	320 4180
Aurora	364 4135
Ft Collins	221 5324
Colo Springs	

THIS COPY RETAINED BY VEHICLE OWNER

INSTRUCTIONS TO LICENSED EMISSIONS MECHANICS

(ONLY a Licensed Emissions Mechanic may perform this inspection.)

NOTICE

The first copy (top) of this form will be scanned electronically.

Please keep the top copy free of dirt or grease.

Do NOT fold, staple, spindle, or mutilate top copy.

Do NOT make ANY marks on the top copy other than specified in directions.

You may make notes on the second or third copies ONLY.

Use ONLY a NUMBER TWO pencil on this form.

Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC:

ENTER:

% CO		
0	4	8

ppm HC			
0	7	5	0

DO NOT ENTER:

% CO		
4	8	0

ppm HC			
7	5	0	0

Except for Item ① (Vehicle Identification Number), after the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be just one circle filled in under each box.

FIRST INSPECTION

A Complete items ① through ⑧

B Do the first test visual and emissions inspection ⑨ and ⑩, (mark PASS or FAIL for CO and HC).

C If the vehicle passes both the visual and emissions inspection, mark "Compliance" ⑰, sign the form ⑱, punch COC ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

D If the vehicle fails the visual or emissions inspection and the adjustments or repairs are done at your station, complete item ⑭ and go on to Step G.

If the vehicle owner wants the work done elsewhere, give him/her the bottom part of page 3 to be filled in by the person who does the work and returned within 10 days for a free reinspection.

REINSPECTION

E If the vehicle was adjusted or repaired by a Licensed Emissions Mechanic, copy the station and mechanic's license numbers from the "Adjustment Verification" form under item ⑭, attach one copy of the "Adjustment Verification" form to page 2, and go on to Step G.

F. If the vehicle was adjusted or repaired by a non-licensed person, complete item ⑬. If the vehicle passes, go on to Step G. If it fails, make the adjustments or repairs required and go on to Step G or mark "Denied" ⑰, sign the form ⑱, punch CD ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

G. If the vehicle failed the first test visual, do the retest visual inspection ⑪, if it passed the first test visual, go on to step H.

H. Do the retest emissions inspection ⑫, (mark PASS or FAIL for CO and HC).

I Record the amount charged for the inspection, the adjustments (if performed), and the labor and parts costs for required repairs ⑯.

J Record any voluntary repairs ⑮.

K. If the vehicle passes both the visual and the emissions retests, mark "Compliance" ⑰, sign the form ⑬, punch COC ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

L. If the vehicle passes the visual retest but fails the emissions retest (and, for 1981's and newer, $100.00 was spent on emissions repairs) mark "Adjustment" ⑰, sign the form ⑱, punch COA ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

M. If the vehicle fails the visual retest (or, for 1981's and newer, fails the emissions retest and less than $100 was spent on emissions repairs) mark "Denied" ⑰, sign the form ⑱, punch CD ⑲, and "Date of Test" on pages 2 and 3, and give both halves of page 3 to the vehicle owner.

GREEN FORM

January, 1982 - Current

Preceding page blank

COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic B10-32041-321

CERTIFICATE NO. ____________ VEH. OWNERS NAME: ____________

① VEHICLE IDENTIFICATION NUMBER

ADDRESS: ____________

____________ CITY: ____________

② AUTO MAKE

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO. DAY YR.

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ MOD. YEAR

⑧ NO. OF CYL.

⑯ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑨ INSPECTION COST — $ $ ¢ ¢

IMPORTANT!

IF EXHAUST SYSTEM LEAKS ENOUGH TO CAUSE POSSIBLE DILUTION OF THE SAMPLE, FILL IN THIS CIRCLE. ○

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑮ FINAL TEST EMISSIONS LEVELS

% CO — Compare these levels to the emissions standards for model year being tested. — ppm HC

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

564450

⑩ FIRST TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER — MECHANIC'S NUMBER — ADJUSTMENT COST ($ $ ¢ ¢)

⑬ EMISSIONS REPAIR COST (81 OR NEWER) — $ $ $ ¢ ¢

⑪ FIRST TEST EMISSIONS LEVELS

% CO — Compare these levels to the emissions standards for model year being tested. — ppm HC

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

____
SIGNATURE OF LICENSED EMISSIONS MECHANIC

USE ONLY A NUMBER TWO (2) PENCIL ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO BE PICKED UP BY DEPARTMENT OF REVENUE

COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic B10-32041-321

TM

CERTIFICATE NO. ____________ VEH. OWNER'S NAME ____________

① VEHICLE IDENTIFICATION NUMBER

ADDRESS ____________

____________ CITY ____________

② AUTO MAKE

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUIK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MERZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

0 1 2 3 4 5 6 7 8 9 A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

④ DATE OF TEST

MO DAY YR

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ [illegible]

⑧ NO. OF CYL.

⑮ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑨ INSPECTION COST

$ $ ¢ ¢

REMARKS: ____________

⑮ FINAL TEST EMISSIONS LEVELS

% CO — Compare these levels to the emissions standards for model year being tested. — ppm HC

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

564450

⑩ FIRST TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑪ FIRST TEST EMISSIONS LEVELS

% CO — Compare these levels to the emissions standards for model year being tested. — ppm HC

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER	MECHANIC'S NUMBER	ADJUSTMENT COST
		$ $ ¢ ¢

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$ $ $ ¢ ¢

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

____
SIGNATURE OF LICENSED EMISSIONS MECHANIC

THIS COPY TO BE FILED AT "AIR" PROGRAM STATION

COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic B10-32041-321

CERTIFICATE NO. ____________ VEH. OWNER'S NAME: ____________

① VEHICLE IDENTIFICATION NUMBER

ADDRESS: ____________ 564450

____________ CITY: ____________

② AUTO MAKE

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO. DAY YR.

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ [illegible]

⑧ NO. OF CYL.

⑩ CERTIFICATION ISSUED

COMPLIANCE ○
ADJUSTMENT ○
DENIED ○

⑨ INSPECTION COST

$ $ ¢ ¢

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑮ FINAL TEST EMISSIONS LEVELS

% CO				ppm HC			
⓪	⓪.⓪	Compare these levels to the emissions standards for model year being tested.		⓪	⓪	⓪	⓪
①	①.①			①	①	①	①
	②.②			②	②	②	②
	③.③				③	③	③
	④.④				④	④	④
	⑤.⑤				⑤	⑤	⑤
	⑥.⑥				⑥	⑥	⑥
	⑦.⑦				⑦	⑦	⑦
	⑧.⑧				⑧	⑧	⑧
	⑨.⑨				⑨	⑨	⑨

CO Ⓟ PASS Ⓟ HC
CO Ⓕ FAIL Ⓕ HC

564450

⑩ FIRST TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑪ FIRST TEST EMISSIONS LEVELS

% CO				ppm HC			
⓪	⓪.⓪	Compare these levels to the emissions standards for model year being tested.		⓪	⓪	⓪	⓪
①	①.①			①	①	①	①
	②.②			②	②	②	②
	③.③				③	③	③
	④.④				④	④	④
	⑤.⑤				⑤	⑤	⑤
	⑥.⑥				⑥	⑥	⑥
	⑦.⑦				⑦	⑦	⑦
	⑧.⑧				⑧	⑧	⑧
	⑨.⑨				⑨	⑨	⑨

CO Ⓟ PASS Ⓟ HC
CO Ⓕ FAIL Ⓕ HC

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER	MECHANIC'S NUMBER	ADJUSTMENT COST
		$ $ ¢ ¢

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$ $ $ ¢ ¢

NOTE TO VEHICLE OWNER

If your vehicle did not pass the first test, you may make any adjustments or repairs yourself or have anyone else do them but, in order to receive a Certification of Emissions Control, your vehicle must meet at least one of the following conditions:

1) Pass both the visual and the emissions final tests, or
2) Pass the visual final test and be adjusted by a licensed emissions mechanic and, for 1981 and newer vehicles, have at least one hundred dollars ($100) in emissions-related repairs done.

FOR ANY ADDITIONAL INFORMATION, CONTACT ONE OF THE FOLLOWING EMISSION TECHNICAL CENTERS:

Denver Metro Area - 9640 E. Colfax Ave., Aurora 364-4135
Fort Collins Area - 429 N. College Ave., Ft. Collins 221-5324
Colo. Springs Area - 1403 S. Tejon St., Colo. Springs 633-2333

OR THE COLORADO DEPARTMENT OF REVENUE 866-5518

EMISSIONS STANDARDS

MODEL YEAR	1968-1971	1972-1974	1975-1976	1977-1978	1979& NEWER
CO(%)	7.0	6.0	5.5	3.5	2.0
HC(ppm)	1200	1200	800	500	400

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

____
SIGNATURE OF LICENSED EMISSIONS MECHANIC

IMPORTANT – KEEP THIS FORM

It will allow you to have one free re-inspection at the original inspection station within ten days if your vehicle fails its first inspection.

THIS COPY TO BE RETAINED BY VEHICLE OWNER

INSTRUCTIONS TO LICENSED EMISSIONS MECHANICS

(ONLY a Licensed Emissions Mechanic may perform this inspection.)

NOTICE

- The first copy (top) of this form will be scanned electronically.
- Please keep the top copy free of dirt or grease.
- Do NOT fold, staple, spindle, or mutilate top copy.
- Do NOT make ANY marks on the top copy other than specified in directions.
- You may make notes on the second or third copies ONLY.
- Use ONLY a NUMBER TWO pencil on this form.
- Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC:
- Except for Item ① (Vehicle Identification Number), after the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be just one circle filled in under each box.

	% CO	ppm HC		% CO	ppm HC
ENTER	0 4.8	0 7 5 0	DO NOT ENTER	4 8.0	7 5 0 0

FIRST INSPECTION

PRINT - Name and address of vehicle owner at top of this form

ITEM

① Vehicle Identification Number - Write in VIN number.

② Auto Make - Fill in circle for auto make.

③ License Plate - Enter license plate number and fill in circles (if temporary tag leave blank, if more than six characters use first six).

④ Date of Test - Enter month, day and year and fill in circles.

⑤ Station Number - Enter your station's license number and fill in circles.

⑥ Mechanic's Number - Enter your emissions mechanic's license number and fill in circles.

⑦ Model Year - Enter last two digits of vehicle's model year and fill in circles (example: 1972 enter 72).

⑧ No. of Cyl. - Enter number of cylinders in engine and fill in circles (if rotary engine enter number of rotors).

⑨ Inspection Cost - Enter cost of inspection in dollars and cents (maximum $10.00) and fill in circles under dollar portion only.

⑩ First Test Visual - For 1981 and older vehicles, fill in "81 OR OLDER" circle (no visual inspection needed).

For 1982 and newer vehicles, fill in "82 OR NEWER" circle, complete first visual inspection and fill in a pass or fail circle for each emissions control system.

⑪ First Test Emissions Levels - Complete first emissions inspection, enter readings and fill in circles. Compare readings to State standards and fill in pass or fail circles for CO and for HC.

NOTE: THIS COMPLETES FIRST INSPECTION. IF VEHICLE HAS PASSED ALL REQUIREMENTS, FILL IN "COMPLIANCE" CIRCLE IN ITEM ⑯ AND SIGN ITEM ⑰. ENTER CERTIFICATE OF EMISSIONS CONTROL NUMBER AT TOP OF FORM, GIVE THIRD COPY TO VEHICLE OWNER AND AFFIX CERTIFICATE OF EMISSIONS CONTROL STICKER TO THE WINDSHIELD AS SPECIFIED.

VEHICLES FAILING FIRST INSPECTION

ITEM

⑫ "AIR" Program Adjustments - If adjustments were made by a licensed emissions mechanic, enter license numbers of station and mechanic where adjustments were made and cost of adjustments in dollars and cents (maximum $15.00). Fill in circles under station number, mechanic's number and dollar portion of adjustment cost. NOTE: If adjustments were made by another licensed emissions mechanic, copy this information from "Adjustment Verification Form".

⑬ Emissions Repair Cost - For 1981 and newer vehicles, enter cost of emissions related repairs in dollars and cents and fill in circles under dollar portion only.

⑭ Final Test Visual - For 1981 and older vehicles, fill in "81 OR OLDER" circle (no visual inspection needed).

For 1982 and newer vehicles, fill in "82 OR NEWER" circle, complete final visual inspection and fill in a pass or fail circle for each emissons control system.

⑮ Final Test Emissions Levels - Complete final emissions inspection, enter readings and fill in circles. NOTE: If adjustments were made by another licensed emissions mechanic, copy readings from "Adjustment Verification Form". Compare readings to State standards and fill in pass or fail circles for CO and for HC.

⑯ Certification Issued - Fill in circle next to:

COMPLIANCE	if item ⑭ passed and item ⑮ is within State standards.
ADJUSTMENT	if item ⑭ passed, item ⑮ failed, adjustments done by licensed mechanic and, for 1981 and newer vehicles, at least $100 spent on emissions related repairs.
DENIED	if item ⑭ failed or item ⑮ failed and 1) adjustments not done by licensed mechanic or 2) for 1981 and newer vehicles, less than $100 spent on emissions repairs.

⑰ Signature of Licensed Emissions Mechanic - After completing this form, sign it, enter number of the certificate issued (or "none" if certification denied) at top of form and give third copy to vehicle owner. If a certification is issued, affix certificate of emissions control sticker to the windshield as specified.

NEWEST INSPECTION FORM

For use beginning July 1, 1982

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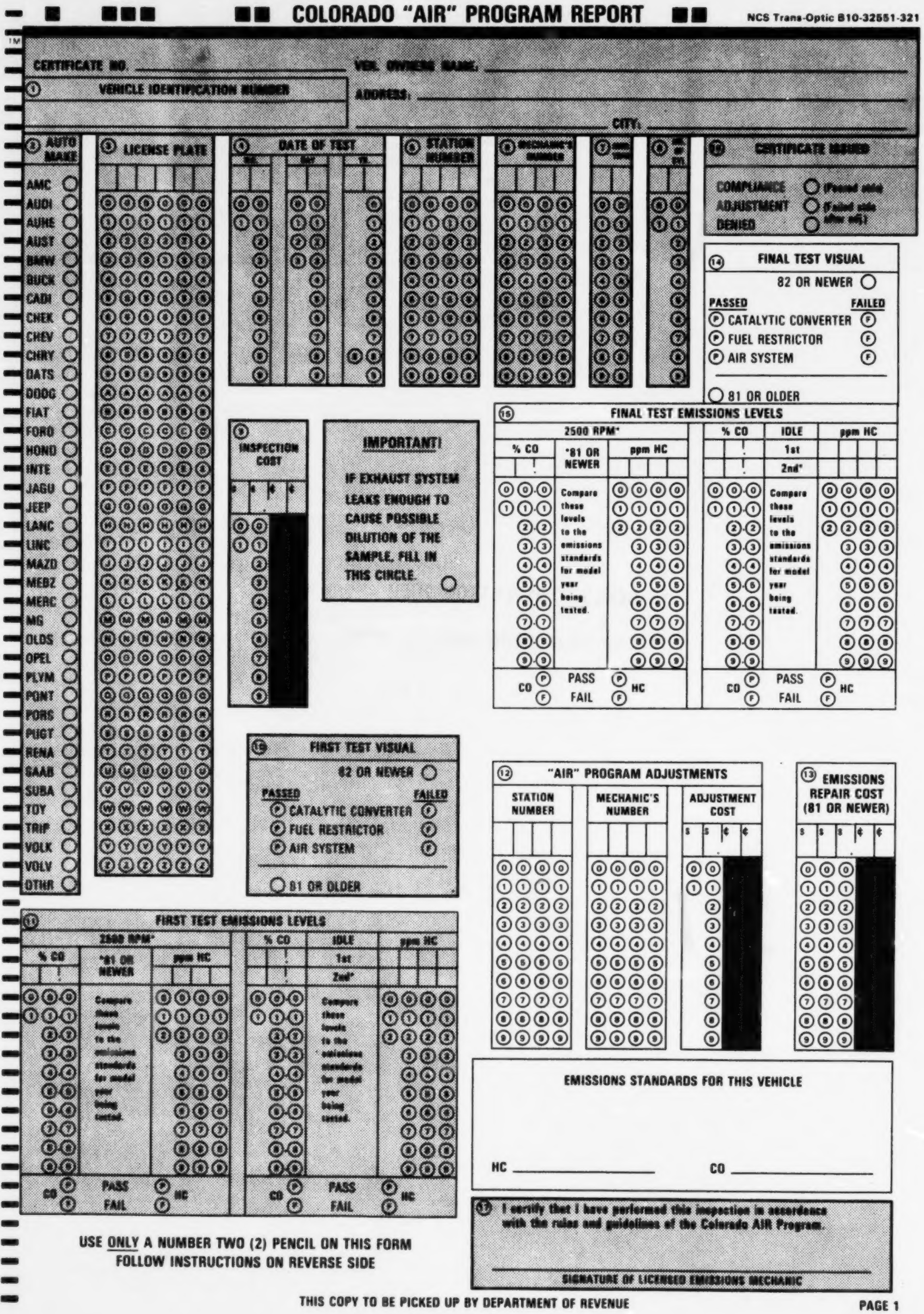


COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic B10-32551-321

CERTIFICATE NO. ____________ VEH. OWNERS NAME: ____________

① VEHICLE IDENTIFICATION NUMBER

ADDRESS: ____________

CITY: ____________

② AUTO MAKE

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST — MO. DAY YR.

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ [illegible]

⑧ NO. OF CYL.

⑩ CERTIFICATE ISSUED

COMPLIANCE ○ (Passed [illegible])
ADJUSTMENT ○ (Failed [illegible] after adj.)
DENIED ○

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑨ INSPECTION COST

$ ¢ ¢

IMPORTANT!

IF EXHAUST SYSTEM LEAKS ENOUGH TO CAUSE POSSIBLE DILUTION OF THE SAMPLE, FILL IN THIS CIRCLE. ○

⑮ FINAL TEST EMISSIONS LEVELS

2500 RPM* — % CO — *81 OR NEWER — ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

% CO — IDLE 1st 2nd* — ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

⑯ FIRST TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER — MECHANIC'S NUMBER — ADJUSTMENT COST ($ $ ¢ ¢)

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$ $ $ ¢ ¢

⑪ FIRST TEST EMISSIONS LEVELS

2500 RPM* — % CO — *81 OR NEWER — ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

% CO — IDLE 1st 2nd* — ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

EMISSIONS STANDARDS FOR THIS VEHICLE

HC ____________ CO ____________

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

____

SIGNATURE OF LICENSED EMISSIONS MECHANIC

USE ONLY A NUMBER TWO (2) PENCIL ON THIS FORM
FOLLOW INSTRUCTIONS ON REVERSE SIDE

THIS COPY TO BE PICKED UP BY DEPARTMENT OF REVENUE

PAGE 1

COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic B10-32551-321

CERTIFICATE NO. ____________ VEH. OWNERS NAME ____________

① VEHICLE IDENTIFICATION NUMBER

ADDRESS ____________

CITY ____________

AUTO MAKE

AMC ○
AUDI ○
AUNE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MERZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

LICENSE PLATE

DATE OF TEST

STATION NUMBER

MECHANIC'S NUMBER

CERTIFICATE ISSUED

COMPLIANCE ○ (Passed side)
ADJUSTMENT ○ (Failed side after adj.)
DENIED ○

INSPECTION COST

$ $ ¢ ¢

REMARKS: ____________

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED / FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ

○ 81 OR OLDER

FINAL TEST EMISSIONS LEVELS

2500 RPM* — % CO | *81 OR NEWER | ppm HC

Compare these levels to the emissions standards for model year being tested.

% CO | IDLE 1st 2nd* | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

FIRST TEST VISUAL

82 OR NEWER ○

PASSED / FAILED
Ⓟ CATALYTIC CONVERTER Ⓕ
Ⓟ FUEL RESTRICTOR Ⓕ
Ⓟ AIR SYSTEM Ⓕ

○ 81 OR OLDER

⑪ FIRST TEST EMISSIONS LEVELS

2500 RPM* — % CO | *81 OR NEWER | ppm HC

Compare these levels to the emissions standards for model year being tested.

% CO | IDLE 1st 2nd* | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER	MECHANIC'S NUMBER	ADJUSTMENT COST
		$ $ ¢ ¢

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$ $ $ ¢ ¢

EMISSIONS STANDARDS FOR THIS VEHICLE

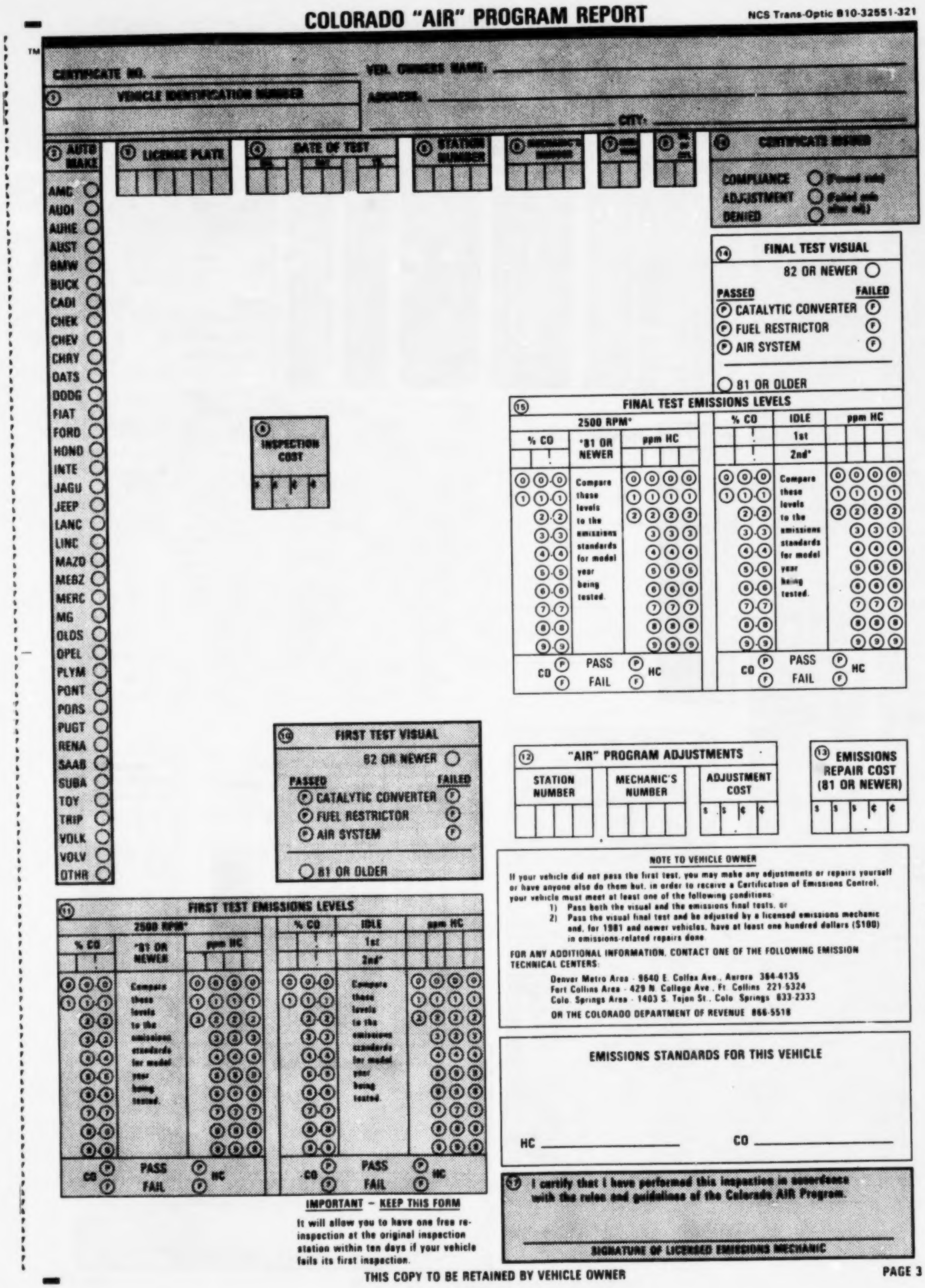
HC ____________ CO ____________

I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

____
SIGNATURE OF LICENSED EMISSIONS MECHANIC

THIS COPY TO BE FILED AT "AIR" PROGRAM STATION

PAGE 2



COLORADO "AIR" PROGRAM REPORT

NCS Trans-Optic 810-32551-321

CERTIFICATE NO. ______

VEH. OWNERS NAME: ______

① VEHICLE IDENTIFICATION NUMBER

ADDRESS: ______

CITY: ______

② AUTO MAKE

AMC ○
AUDI ○
AUHE ○
AUST ○
BMW ○
BUCK ○
CADI ○
CHEK ○
CHEV ○
CHRY ○
DATS ○
DODG ○
FIAT ○
FORD ○
HOND ○
INTE ○
JAGU ○
JEEP ○
LANC ○
LINC ○
MAZD ○
MEBZ ○
MERC ○
MG ○
OLDS ○
OPEL ○
PLYM ○
PONT ○
PORS ○
PUGT ○
RENA ○
SAAB ○
SUBA ○
TOY ○
TRIP ○
VOLK ○
VOLV ○
OTHR ○

③ LICENSE PLATE

④ DATE OF TEST

⑤ STATION NUMBER

⑥ MECHANIC'S NUMBER

⑦ [illegible]

⑧ [illegible]

⑬ CERTIFICATE ISSUED

COMPLIANCE ○ (Passed only)
ADJUSTMENT ○ (Failed only after adj.)
DENIED ○

⑭ FINAL TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑨ INSPECTION COST

$ $ $ $

⑮ FINAL TEST EMISSIONS LEVELS

2500 RPM*

% CO | *81 OR NEWER | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

% CO | IDLE 1st 2nd* | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

⑩ FIRST TEST VISUAL

82 OR NEWER ○

PASSED		FAILED
Ⓟ	CATALYTIC CONVERTER	Ⓕ
Ⓟ	FUEL RESTRICTOR	Ⓕ
Ⓟ	AIR SYSTEM	Ⓕ

○ 81 OR OLDER

⑫ "AIR" PROGRAM ADJUSTMENTS

STATION NUMBER	MECHANIC'S NUMBER	ADJUSTMENT COST
		$ $ ¢ ¢

⑬ EMISSIONS REPAIR COST (81 OR NEWER)

$ $ $ ¢ ¢

⑪ FIRST TEST EMISSIONS LEVELS

2500 RPM*

% CO | *81 OR NEWER | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

% CO | IDLE 1st 2nd* | ppm HC

Compare these levels to the emissions standards for model year being tested.

CO Ⓟ PASS Ⓟ HC
Ⓕ FAIL Ⓕ

NOTE TO VEHICLE OWNER

If your vehicle did not pass the first test, you may make any adjustments or repairs yourself or have anyone else do them but, in order to receive a Certification of Emissions Control, your vehicle must meet at least one of the following conditions:

1) Pass both the visual and the emissions final tests, or
2) Pass the visual final test and be adjusted by a licensed emissions mechanic and, for 1981 and newer vehicles, have at least one hundred dollars ($100) in emissions-related repairs done.

FOR ANY ADDITIONAL INFORMATION, CONTACT ONE OF THE FOLLOWING EMISSION TECHNICAL CENTERS:

Denver Metro Area - 9640 E. Colfax Ave., Aurora 364-4135
Fort Collins Area - 429 N. College Ave., Ft. Collins 221-5324
Colo. Springs Area - 1403 S. Tejon St., Colo. Springs 633-2333
OR THE COLORADO DEPARTMENT OF REVENUE 866-5518

EMISSIONS STANDARDS FOR THIS VEHICLE

HC ______ CO ______

⑰ I certify that I have performed this inspection in accordance with the rules and guidelines of the Colorado AIR Program.

SIGNATURE OF LICENSED EMISSIONS MECHANIC

IMPORTANT – KEEP THIS FORM

It will allow you to have one free re-inspection at the original inspection station within ten days if your vehicle fails its first inspection.

THIS COPY TO BE RETAINED BY VEHICLE OWNER

PAGE 3

INSTRUCTIONS TO LICENSED EMISSIONS MECHANICS

NOTICE: Only a Licensed Emissions Mechanic may perform this inspection.

- Page 1 (top copy) of this form will be scanned electronically.
- Please keep page 1 free of dirt or grease.
- Do NOT fold, staple, spindle, or mutilate page 1.
- Do NOT make ANY marks on page 1 other than specified in directions.
- You may make notes on pages 2 and 3 ONLY.
- Use ONLY a NUMBER TWO pencil on this form.
- Where boxes are provided put one and only one number or letter in each box, if there are more boxes than numbers or letters put enough zeroes in front (to the left) to fill up the extra boxes. For example, if the emission levels are 4.8% CO and 750 ppm HC

ENTER

% CO			ppm HC			
0	4	8	0	7	5	0

DO NOT ENTER

% CO			ppm HC			
4	8	0	7	5	0	0

- After the boxes are marked, fill in the circle under each box which has a letter or number that matches the letter or number in the box above. There should be one and only one circle filled in under each box.

FIRST INSPECTION

PRINT - Name and address of vehicle owner at top of this form.

ITEM

① Vehicle Identification Number - Write in VIN number.

② Auto Make - Fill in circle for auto make.

③ License Plate - Enter license plate number and fill in circles (if temporary tag leave blank, if more than six characters use first six).

④ Date of Test - Enter month, day and year and fill in circles.

⑤ Station Number - Enter your station's license number and fill in circles.

⑥ Mechanic's Number - Enter your emissions mechanic's license number and fill in circles.

⑦ Model Year - Enter last two digits of vehicle's model year and fill in circles (example: 1972 enter 72).

⑧ No. of Cyl. - Enter number of cylinders in engine and fill in circles (if rotary engine enter number of rotors).

⑨ Inspection Cost - Enter cost of inspection in dollars and cents (maximum $10.00) and fill in circles under dollar portion only.

⑩ First Test Visual -

1981 AND OLDER VEHICLES: Fill in "81 OR OLDER" circle. (No visual inspection needed.)

1982 AND NEWER VEHICLES: Fill in "82 OR NEWER" circle, complete first visual inspection and fill in a pass or fail circle for each emissions control system.

⑪ First Test Emissions Levels -

1968-1980 VEHICLES: Complete first test emissions inspection, enter readings in 1st IDLE boxes and fill in proper circles below. Compare readings with State emissions standards and fill in pass or fail circles for CO and for HC.

1981 AND NEWER VEHICLES: Complete first test two speed emissions inspection, enter readings in 1st IDLE, 2500 RPM and 2nd IDLE boxes. Fill in the proper circles under 2500 RPM - %CO and ppm HC (left half of block ⑪). From the right half of block ⑪ select the lowest IDLE CO reading of the two idle tests and fill in the proper circles under IDLE %CO. Then select the lowest IDLE HC reading (from either idle test) and fill in the proper circles under IDLE ppm HC. Compare 2500 RPM and IDLE readings marked in the circles with State emissions standards and fill in CO and HC pass or fail circles for each speed. (Vehicles must pass at both 2500 RPM and idle to pass the first test.)

NOTE: THIS COMPLETES FIRST INSPECTION. IF VEHICLE HAS PASSED ALL REQUIREMENTS, FILL IN "COMPLIANCE" CIRCLE IN ITEM ⑯ AND SIGN ITEM ⑰. ENTER CERTIFICATE OF EMISSIONS CONTROL STICKER NUMBER AT TOP OF FORM AND AFFIX STICKER TO THE WINDSHIELD AS SPECIFIED. GIVE PAGE 3 OF REPORT FORM TO VEHICLE OWNER.

VEHICLES FAILING FIRST INSPECTION

ITEM

⑫ "AIR" Program Adjustments - If adjustments were made by a licensed emissions mechanic, enter license numbers of station and mechanic where adjustments were made and cost of adjustments in dollars and cents (maximum $15.00). Fill in circles under station number, mechanic's number and dollar portion of adjustment cost.
NOTE: If adjustments were made by another licensed emissions mechanic, copy this information from "Adjustment Verification Form".

⑬ Emissions Repair Cost - For 1981 and newer vehicles only, enter cost of emissions related repairs in dollars and cents and fill in circles under dollar portion only. Repair costs do not include inspection or initial adjustment fees, or any costs required to pass the visual inspection.

⑭ Final Test Visual -

1981 AND OLDER VEHICLES: Fill in "81 OR OLDER" circle. (No visual inspection needed.)

1982 AND NEWER VEHICLES: Fill in "82 OR NEWER" circle, complete final visual inspection and fill in a pass or fail circle for each emissions control system. (All three systems must be marked "PASSED" in order for a certificate of emissions control to be issued.)

⑮ Final Test Emissions Levels - If adjustments were made by another licensed emissions mechanic, copy data for blocks ⑫ and ⑮ from "Adjustment Verification Form."

1968-1980 VEHICLES: Complete final test emissions inspection, enter readings in 1st IDLE boxes and fill in proper circles below. Compare readings with State emissions standards and fill in pass or fail circles for CO and for HC.

1981 AND NEWER VEHICLES: Complete final test two speed emissions inspection and enter readings and fill in circles as described in item ⑪. Compare readings with State emissions standards and fill in CO and HC pass or fail circles for each speed.

⑯ Certificate Issued - Fill in circle next to:

COMPLIANCE	Only if item ⑭ passed and item ⑮ is within State emissions standards.
ADJUSTMENT	Only if item ⑭ passed, item ⑮ failed, adjustments made by a licensed emissions mechanic and, for 1981 and newer vehicles, at least $100 was spent on emissions related repairs.
DENIED	Only if item ⑭ failed or item ⑮ failed and 1) adjustments not made by a licensed emissions mechanic or 2) for 1981 and newer vehicles, less than $100 was spent on emissions repairs.

⑰ Signature of Licensed Emissions Mechanic - After completing this form, sign it, enter number of the sticker issued (or "none" if certification denied) at top of report form and give page 3 to vehicle owner. If a certificate is issued, affix certificate of emissions control sticker to the windshield as specified.

APPENDIX E

The following excerpts are from Forms Design Guide: Reference Manual, Sentry Optical Mark Reading Systems, a training booklet developed by National Computer Systems, Inc. (NCS) for its customers. It provides guidelines for designing forms for the NCS optical mark reading system and in doing so, provides information about optical mark systems in general.

Reproduced with the permission of National Computer Systems, Inc. The interested reader is advised to obtain the entire document from NCS.

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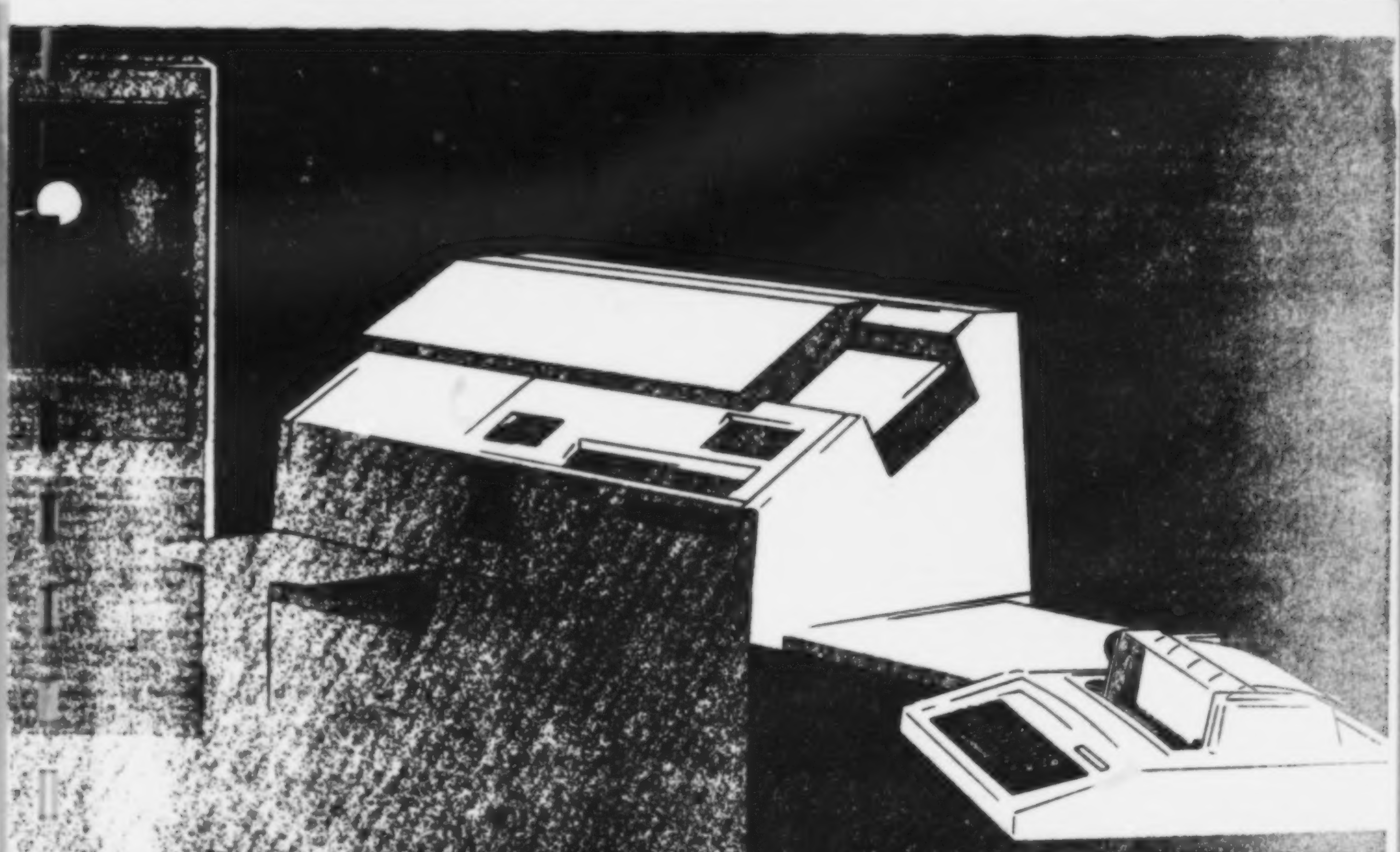

NATIONAL
COMPUTER
SYSTEMS, INC.

FORMS DESIGN GUIDE

Reference Manual

Sentry Optical Mark Reading Systems

[illegible]

OVERVIEW OF SCANNING

WHAT IS SCANNING?

Scanning is the process of reading information from a document using either an optical mark reader or an optical character reader. This process involves changing the information on the document into a set of electronic signals which can then be stored in the computer's memory. Simply stated then, scanning is another word for inputting data into a computer.

Scanning however, has a number of advantages over other standard means of input, such as keypunching. Because the answers marked by the respondent are read directly by the scanner, the need to transcribe data is eliminated. Obviously the data will get into the system faster and with fewer errors. The net result is faster turn-around time and more accurate data. Because scanning requires only a paper and pencil for input, the costs of data collection are reduced.

The primary purpose or the objective of scanning is to translate data on a sheet of paper into information a computer can understand. In order to accomplish this, a certain sequence of events must take place.

The first step in the scanning process is to design a form that will collect the desired information. These documents may be such forms as test answer sheets, order entry forms, or staff surveys. Secondly, once the form is completed, the programmer writes and tests a program to read these documents. After this stage, the documents themselves are filled out.

The fourth step is the actual scanning itself. During this step the documents are processed and an output record is obtained. This record consists of all the information you desired from the forms.

The final step is the processing of the information by your main computer. This processing will format the information into usable data. It is at this stage that your complete written report of results will be produced.

WHAT IS A SCANNER?

A scanner is a system designed to read marks on a sheet of paper. This system usually consists of several parts: A document feed mechanism (input hopper), document transport bed, scanning station (read head), document output trays (output hoppers), and some sort of controlling logic. The document feed starts the forms into the scanner, the transport bed carries the forms through the scanner, and the output trays receive the scanned forms.

NCS scanners are called optical mark readers (OMR). This is in contrast to alternative readers known as optical character readers (OCR). An OMR is a device that detects the absence or presence of a mark, but not the shape of the mark. An OCR is a device that resolves the actual character printed.

The scanning station or read head consists of a collection of light sources called light emitting diodes (LEDs) and a collection of photo-sensitive cells that convert the emitted light into electrical signals. There are two basic types of reading techniques: reflected light read and transmitted light read.

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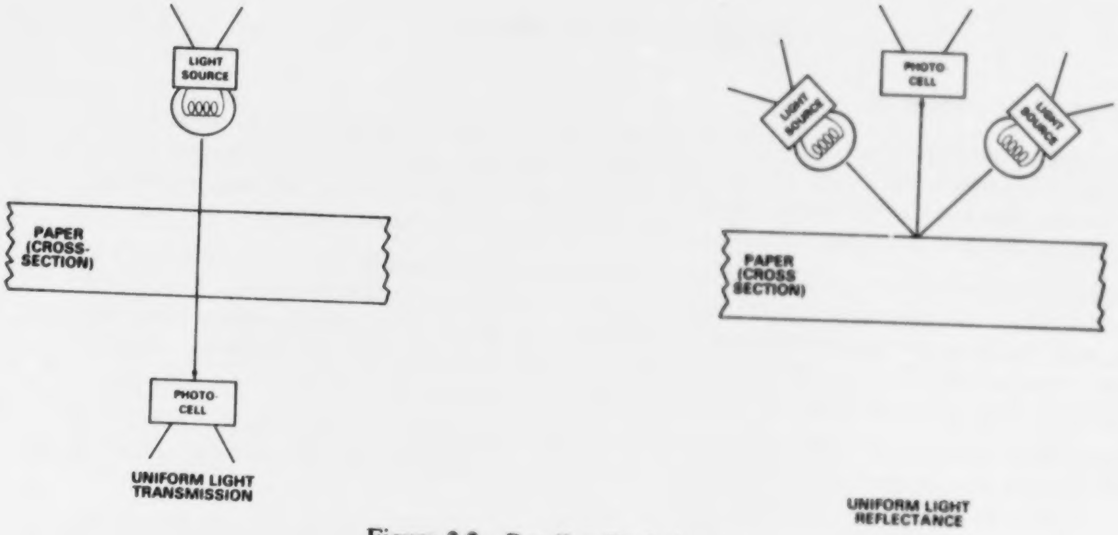


UNIFORM LIGHT TRANSMISSION

UNIFORM LIGHT REFLECTANCE

Figure 2.2 Reading Techniques

In the reflected light reading system, there are two lamps placed above and at 45° angles to the document. These lamps serve as the light source. Between these lamps is a photocell which serves as receiving station. As the "white" part of a document passes under the photocell, a certain amount of light is reflected into the photocell from the lamps. When a "mark" on the document passes under the photocell, the amount of light reflected into the photocell is quite a bit less than that reflected from the "white" paper.

The same basic equipment is used in the transmitted light read as in the reflected light read with the difference being its placement. In the transmitted light system, the lamps are above and perpendicular to the document while the photocells are placed below the document. All Sentry systems are transmitted light or Trans-Optic® OMR systems.

In the NCS system there are 48 lamps and 48 photocells. This means that there may be a maximum of 48 positions that can be read across the width of the document. One of these positions is occupied with a timing mark that cues the scanner to read across the form. Therefore, there are 47 possible positions for responses across the form.

16 LEVEL READ

As the document passes through the read head, a certain amount of light is blocked by the document. This is called the paper level. As a "mark" passes through the read head, more light is blocked. The amount of light blocked in each position is measured by one of sixteen values, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. The value 7 indicates a very light mark and F represents a very dark carbon mark. This is the NCS sixteen level read which permits careful discrimination between marks.

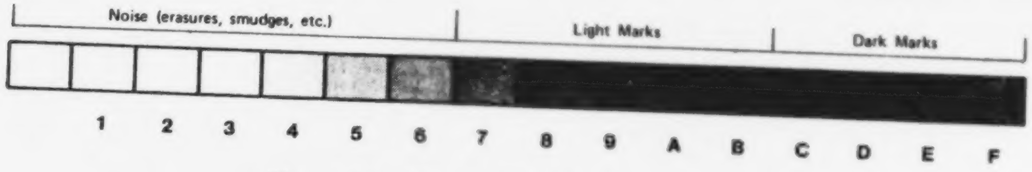


Figure 2.3 Mark Discrimination Levels

INTRODUCTION

This manual is intended to provide the necessary information and specifications for the design of forms for NCS optical mark reading systems. It was designed to provide the information, rules, recommendations, and mock-up techniques needed to design a form to meet the needs of a given application.

The first three chapters of the manual introduce the user to the scanning process, an overview of forms design, and the design process. These chapters are not intended to be a complete course in the process of forms design. For instruction in techniques and demonstration of forms design, see the Forms Design Self Instruction Manual (202 147 906).

The remainder of the manual is organized into a reference manual format that will allow quick location of specifications dealing with any given topic. Once again, it is assumed that the user has had experience or instruction in the basics of forms design and will simply be referring to specific recommendations and regulations for a particular application. Use of the table of contents and index will facilitate finding needed information. With these guidelines, the designer can then be free to allow ideas and needs of the application to structure the form.

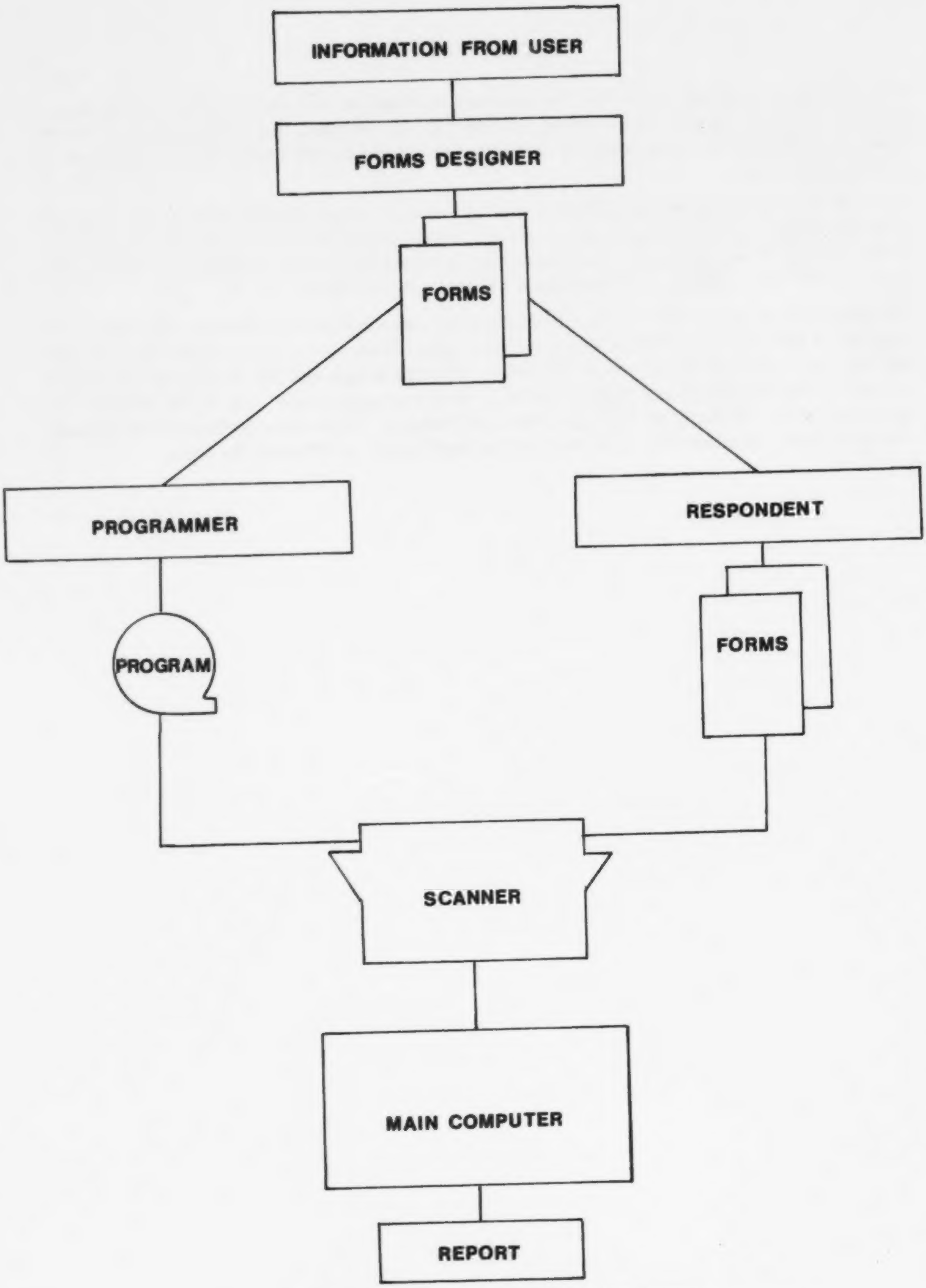

INFORMATION FROM USER
FORMS DESIGNER
FORMS
PROGRAMMER
RESPONDENT
PROGRAM
FORMS
SCANNER
MAIN COMPUTER
REPORT

Figure 2.1 Overview of the Scanning Process

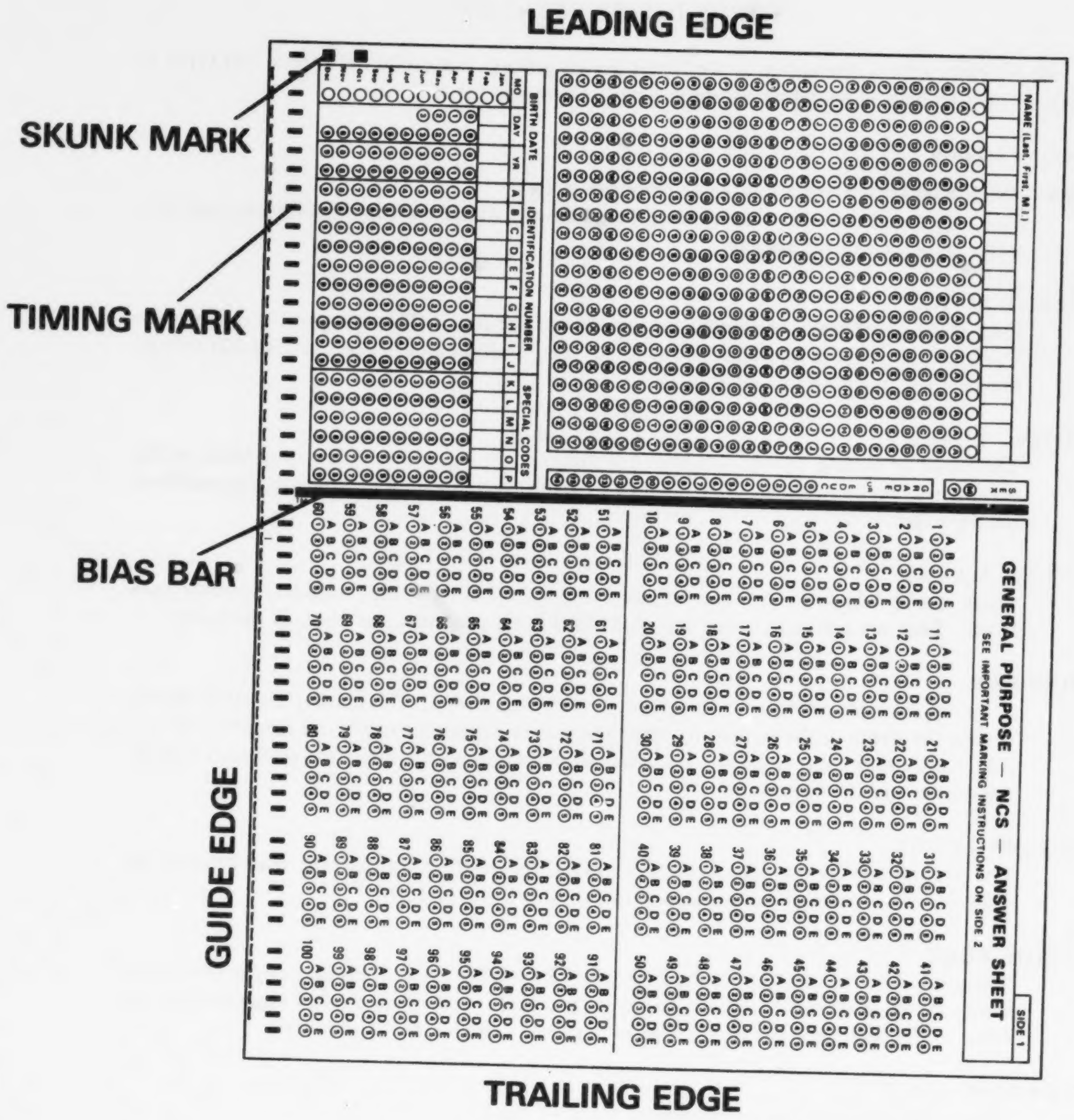

LEADING EDGE
SKUNK MARK
TIMING MARK
BIAS BAR
GUIDE EDGE
TRAILING EDGE
GENERAL PURPOSE — NCS — ANSWER SHEET
SEE IMPORTANT MARKING INSTRUCTIONS ON SIDE 2
SIDE 1
NAME (Last, First, M.I.)
BIRTH DATE
MO
DAY
YR
IDENTIFICATION NUMBER
SPECIAL CODES
SEX
GRADE OR EDUC

Figure 2.4 Parts of a Form

FORMS DESIGN OVERVIEW

Before we enter into a discussion of the forms design process, the quality of forms, and types of forms, it will be helpful to define common terms relating to forms.

Parts of a Form

RESPONSE POSITION (also bubble or response circle)
The circles on the forms that indicate the positions which are capable of being read by a single photocell in the scanner.

TIMING MARK
One of the short black rectangles on the edge of the form. They are printed in machine-readable ink on front and back of the form. The timing mark triggers the scanner to read the response position in that row.

TIMING TRACK
The series of timing marks running in a straight line along one of the long edges of the document. To be scanned, there must be a timing mark for each row of response positions on the page.

SKUNK MARKS
Black marks which occupy one or more response positions, they uniquely identify each form. They are printed in machine-readable ink on the front and back of the form.

BIAS BAR
A bar of ink, the color in which the document was printed. The bar has no other marks. It runs the width of the document perpendicular to the timing track and is printed on one side only, either front or back. The bias bar is used to ensure that each photocell is reading within specific tolerances.

LEADING EDGE
The leading edge is the edge of the form which passes first through the read head of the scanner. The leading edge is parallel to the X-axis of the form.

GUIDE EDGE
The guide edge of the form is the edge with the timing track. This is the edge that slides along the edge of the document transport bed and is critical to correct alignment of the form in the scanner. The guide edge is parallel to the Y-axis of the form.

TRAILING EDGE
This is the edge that passes last under the read head.

RESPONSE MASTER (also called response matrix)

All the possible response positions on a single page. Across the form, perpendicular to the timing track, the bubbles are spaced six per inch to exactly match the photocell spacing in the scanner read head. Down the length of the form, bubbles and timing marks are spaced at either six per inch to yield a uniform matrix or at five per inch so that this dimension is line printer compatible. For example, an 8 1/2" x 11" form is 47 positions wide by 63 positions long for a total of 2961 possible response positions when using the 6 x 6 master.

Therefore, there are two basic masters or matrixes: 6 x 6 and 6 x 5. Only one split is allowed, but may be placed anywhere along the timing track. The split master layout sheet can be made by splicing one of each kind together. Spacing perpendicular to the timing track must always be six per inch to match the read head spacing.

LAYOUT SHEET

A printed copy of the NCS response master. It shows all possible response positions and timing marks. The response master is printed on both sides of the layout sheet for ease of doing two-sided designs.

MOCK-UP

A pencil drawing on an NCS layout sheet that shows exactly where copy, lines, responses, etc. are to be positioned.

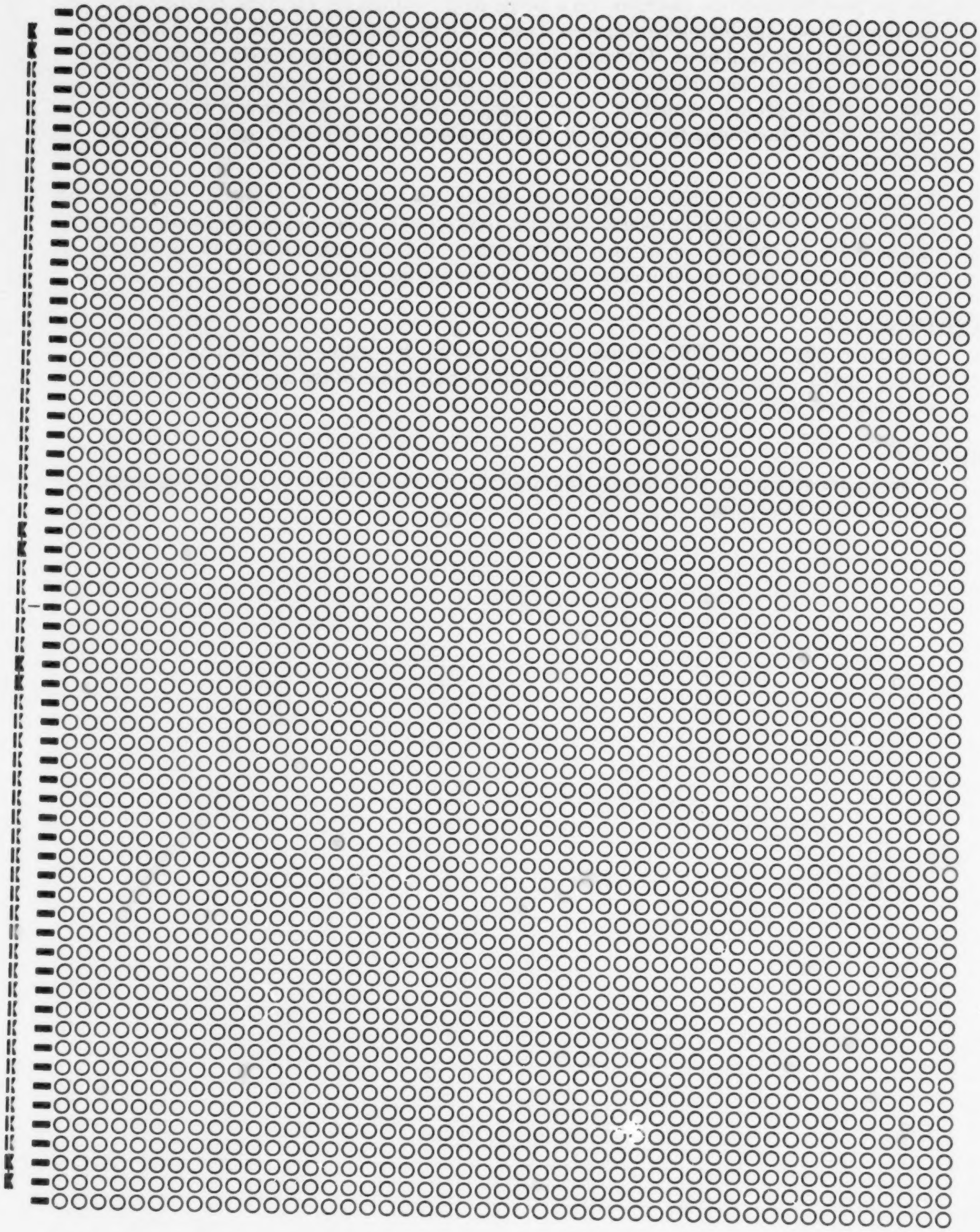


Figure 2.5 Response Master

SUCCESSFUL FORMS DESIGN

NCS scanners represent a "systems" approach to optical mark reading. This means that each component of the system — scanner, software, and forms — must be designed to function well if the system is to be used to its full potential.

The forms component is important because the forms are the means by which data is entered into the scanner. The respondent, the person supplying the information, marks directly on the form and the form is fed directly into the scanner. Because of this direct route of data, it is essential that the form be designed so that the respondent can understand the instructions, and can mark the form quickly, completely, and accurately. If the respondents are confused as to how to mark their responses and where to mark them, it is unlikely that accurate data collection will be possible. While the scanner and software are designed to catch problems and identify errors, no amount of system sophistication can be built to correct the inaccuracies and missing data that results from a confused respondent.

The first requirement of a forms design then, must be that it clearly identifies its own function (has a title), tells the respondent what is wanted (has instructions), and provides a place for a response. A good or successful forms design must do more than that, however. It must also be:

- Compatible with the scanner model being used
- Able to be programmed with efficiency
- Adapted to the age and environment of the respondents
- Adapted to special needs such as mailing or carbon copies

The above list is only a sample of the requirements that may be placed on a forms design. Further discussion of this is found in the section on background information.

The NCS OMR System has been designed to give the forms designer as much flexibility as possible. While it is true that there are some basic rules that must be followed, the rules do not usually dictate design or how the form is used. The forms design follows functional requirements that are defined for the application. A good forms design is one that does the required job of data collection.

Example:

1. If line printing is required on a form, that function requires the form to be continuous and the design to be compatible with line printer spacing. Once this requirement has been met, the designer has many options as to the layout of the form.
2. If a name and identification number are data that must be collected on the form, there are some standard ways to capture alphabetic and numeric data, but the designer is free to place or to orient the data field in almost any way desired.

THE DESIGN PROCESS

There are several important steps to be followed in the process of designing a successful form:

1. Find out the background information. Who is the user? Who is the respondent? What is the purpose of the form? How will it be used?
2. Identify some of the general form requirements such as size, content, and type of form.
3. Identify specific details of the design. Who will sign off on the design? What forms handling equipment will be used? What scanner model? What scanner software?
4. Prepare a rough draft.
5. Prepare a second draft.
6. Prepare a final draft.
7. Review requirements against the final design.
8. Submit design to NCS for composition and printing.

NCS is interested in providing the best possible forms composition and printing. To that end we would like to ask you, the designer, to provide us with clearly drawn mock-ups and complete specifications. When your mock-up is received at NCS, it is examined by experienced NCS forms designers. If your mock-ups and specifications are clear and precise, they will go directly to our composition department. If not, we will contact you with our questions.

Before the actual printing of the form, NCS will send you a copy of the final composition of the form (called a proof) for your approval. Actual printing will not begin until we receive your written approval on the proof.

FORMS QUALITY

There are NCS technicians at each stage of production to ensure that you achieve a high quality form. In addition to helping you in the design process, they monitor the quality of materials and printing.

Sentry scannable documents are printed on Trans-Optic® bond paper which is manufactured exclusively for National Computer Systems. Since the Sentry scanners read **through** the paper, it is important that translucency of the paper, as well as all other facets that affect the scanner both electronically and mechanically, be carefully monitored.

the consistent quality of Trans-Optic® bond paper is ensured beginning at the paper mill where the paper is produced. NCS has placed a unique transmitted light scanning device there to monitor paper inconsistencies caused by inherent differences in the various pulps used and variations created in the mixing process. This checking ensures uniform readability of the paper on which your form is printed.

The ink is monitored in a similar program. All ink is formulated for NCS by the ink manufacturer to meet scanner specifications. Since black ink must be read and color ink must be virtually transparent to the scanner, each ink formula and batch is tested on Trans-Optic® bond and a Sentry scanner to ensure that it conforms to specifications.

Finally, the paper and the ink are tested together on the finished form product. In conjunction with this procedure, forms are pulled at regular intervals during printing and checked for appearance, registration, and read-head alignment.

NCS Scannable Documents Guarantee:

All scannable documents produced by NCS are subject to the highest standards of quality control. Every phase of production from the manufacture of paper to the method of packaging is checked to ensure that all specifications are met. Check sheets from every printing are scanned prior to shipment as a final quality control measure.

National Computer Systems has an outstanding reputation for service and quality. In the unlikely event that a problem should occur, NCS will either replace any unacceptable or unscannable documents or assume the costs of alternative data capture up to a mutually agreed upon dollar amount.

BASIC DESIGN PROCESS

The steps to be followed in the process of designing a successful form are described below.

BACKGROUND INFORMATION

Before a pencil ever touches the layout sheet, the forms designer must learn as much as possible about the form and how it will be used. The more that is known about the requirements of the application, the greater the chance that the design will be successful. Below is a list of some of the most common points to investigate. As you develop your own applications, you will surely add to the list.

GENERAL BACKGROUND

1. Identify purpose of form. What is the user trying to accomplish with the form? What information does the user need?
2. Identify the user. Who will be using the information collected on the OMR form?
3. Identify the respondent. Who will be marking the form? What characteristics, such as age and education, do the respondents have that may affect forms design?
4. Identify how the form will be used. What environment will it be marked in (classroom, truck, cab, office, etc.)? How may the respondent be expected to handle it? Will it also be handled by someone other than the respondent? Will it be mailed? Does the respondent have previous experience with OMR forms?
5. Identify other overall requirements. Are there cost limitations? When are finished forms needed?

SPECIFIC ELEMENTS TO BE INCLUDED:

1. What specific information is being requested on the form?
2. What format is required for each piece of data?
3. What instructions will the respondent need to complete the form correctly?
4. What marking instructions and examples will be needed?
5. What type of form is required? Cut? Continuous?
6. What size is required? Does size meet scanner and printing specifications?
7. Is there a desired sequence for data fields on the form?
8. Will all text be included on the form or is this to be an answer sheet with text on a separate page?
9. Are the specifications flexible? How much freedom does the designer have?

OTHER DETAILS

1. The forms designer will need to consult with other people involved with the form, such as the Sentry Programmer. Identify all such people and make sure they have approval responsibility over the final design.
2. How will the form be handled? Will it be mailed? Folded? Line printed?
3. What model scanner will be used? How will scanner specifications affect forms design?
4. What scanner software (programs) will be used? How will software specifications affect forms design?

ROUGH DRAFT

The purpose of a rough draft is to determine approximately how much space the response areas will require, how they will fit on the page in general, and what space will remain for other needed information. Each of the items on a form are sketched onto an NCS Layout Sheet.

Layout Sheet

To start a rough draft, begin with the NCS layout sheet. Your first question will be which master to use, 6x6, 6x5, or split? The choice of master depends almost entirely on the requirements of your design.

FORMS DESIGN HINT: Choice of layout masters

A 6 x 6 master has the greatest response density. It is used on most cut sheets and allows the greatest amount of data to be on the sheet.

A 6 x 5 master is designed for line printer compatibility when it is oriented horizontally. It may also be used for cut sheet forms where more space between columns of circles is desired.

Split masters make the most of both formats: A 6 x 6 section for best use of available space and a 6 x 5 section for line printer compatibility.

Fitting Form Parts

Since skunk marks and bias bar are critical parts of the design and suggested positions are shown on the layout sheet, begin by marking them on the layout sheet. Next you fit in the grids. Fitting the largest items first will enable you to see how much effect these areas have on the overall design. Then the smaller grids can be sketched into appropriate locations.

You will find that, as you fit grids onto the layout sheet, each grid could just as well have been positioned in some other location on the form, since there is no inherent restriction in location or orientation. It is usually a good idea however, to have all areas of a form oriented in the same direction so that the respondent does not have to turn the form from side to side.

Once you have your grids sketched, you must fill in the title and instructions. By rearranging the grids for the best design, there should be adequate space for the title and instructions.

For your first designs, you may want to try several rough drafts for each form. Don't hesitate to use as many layout sheets as necessary. They are provided by NCS at no charge.

FORMS DESIGN HINT: Cut and Paste

While many find this Rough Draft approach is the easiest way to work up a design, others prefer the Cut and Paste method. With this method you cut out pieces from an existing form that meet your new form requirements. You then rearrange the pieces until you arrive at a pleasing and efficient design. Finally, the pieces are pasted in place and your rough draft is almost finished.

Even when the pieces are pasted to an NCS layout sheet, the pieces will not quite actually fit the space. It is therefore necessary to take a fresh layout sheet and draw an accurate mock-up. Doing this additional step will ensure that the design works the way you want.

Please do not submit cut and paste work to NCS as a final draft.

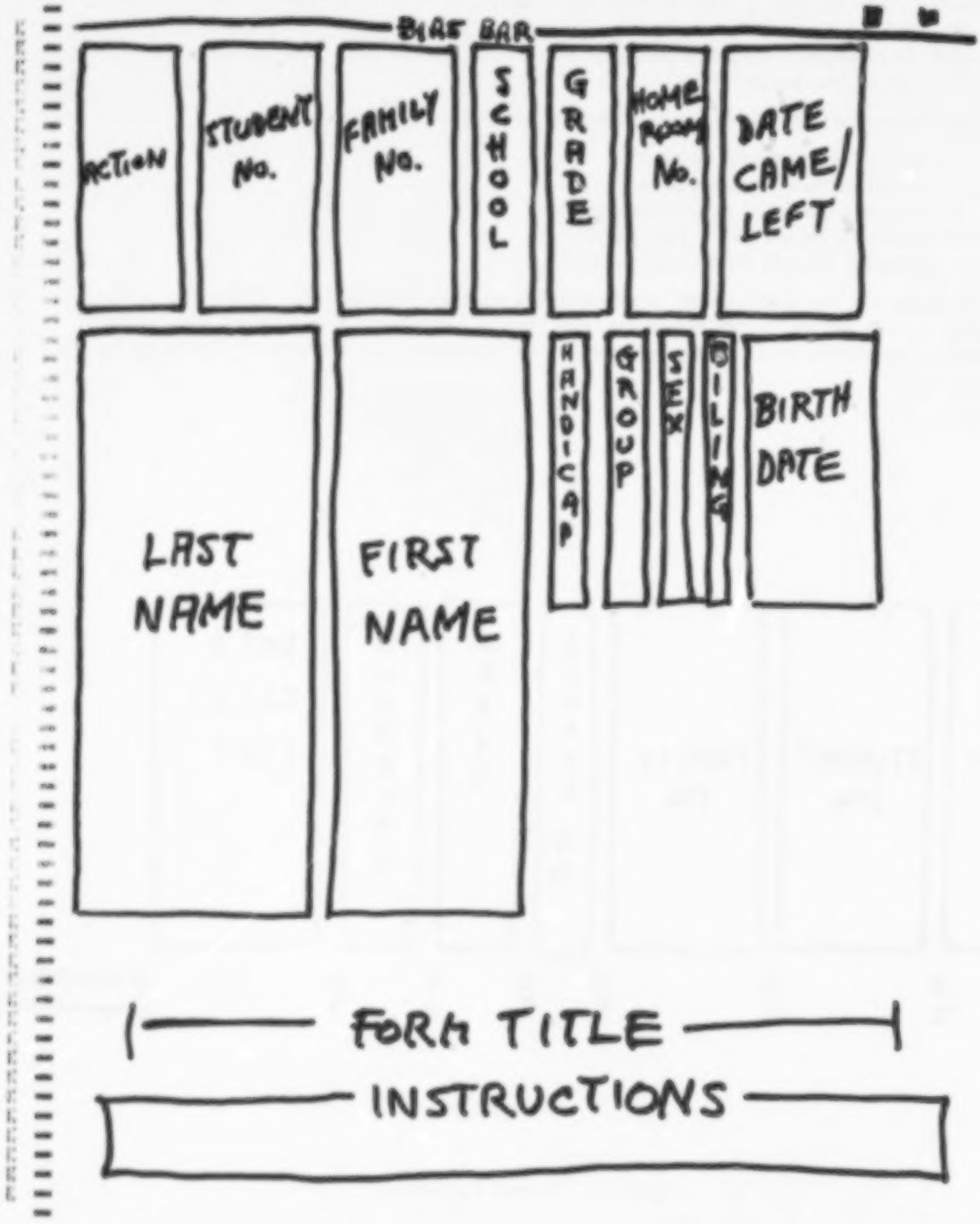

BIAS BAR
ACTION
STUDENT No.
FAMILY No.
SCHOOL
GRADE
HOME ROOM No.
DATE CAME/LEFT
LAST NAME
FIRST NAME
HANDICAP
GROUP
SEX
BILLING
BIRTH DATE
FORM TITLE
INSTRUCTIONS

Figure 3.1 Sample Rough Draft

SECOND DRAFT

Drawing the rough draft is only the first stage in the mock-up process. Returning to the original draft, you must evaluate and make improvements on each section. It is at this stage that you spread out some grids, squeeze others together, try different formats for grids, and make room for additional information.

When the second draft of the form is complete, check your progress:

Are all data elements included?
Is each element the correct size?
Are the elements in the desired sequence?
Are the grids spaced for easy readability?
Does the form fit the format specified?

Depending on your organization, you should seek approval from any individuals who must approve or sign off the design before the final draft is completed. For users who are not very familiar with OMR forms, it may be necessary to complete a final draft before asking for their approval.

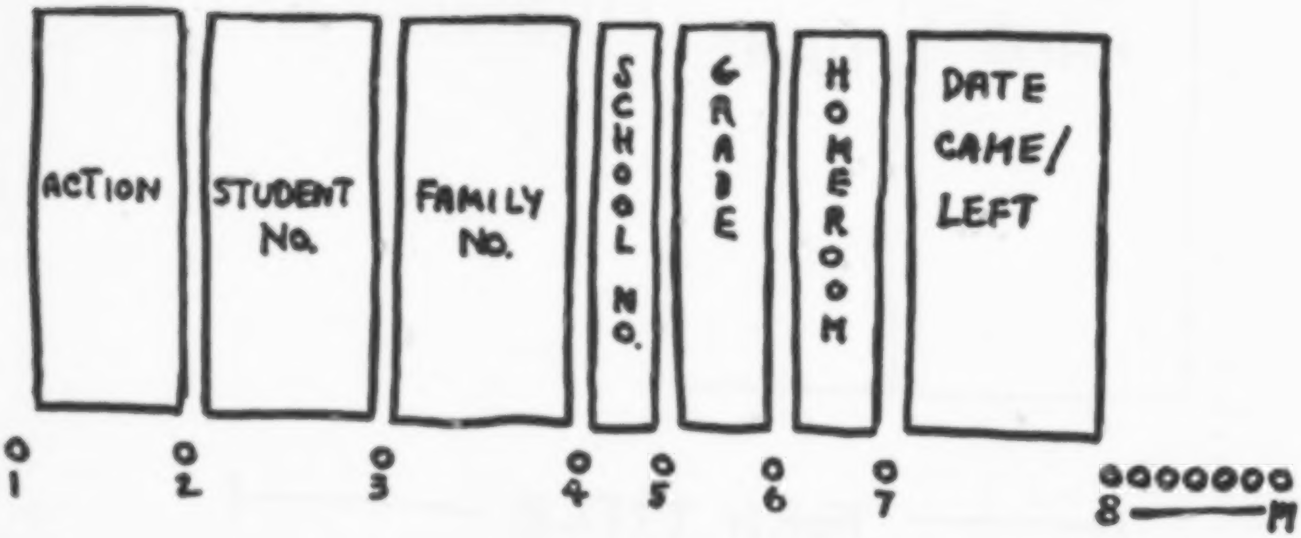


Figure 3.2 Sample First Draft

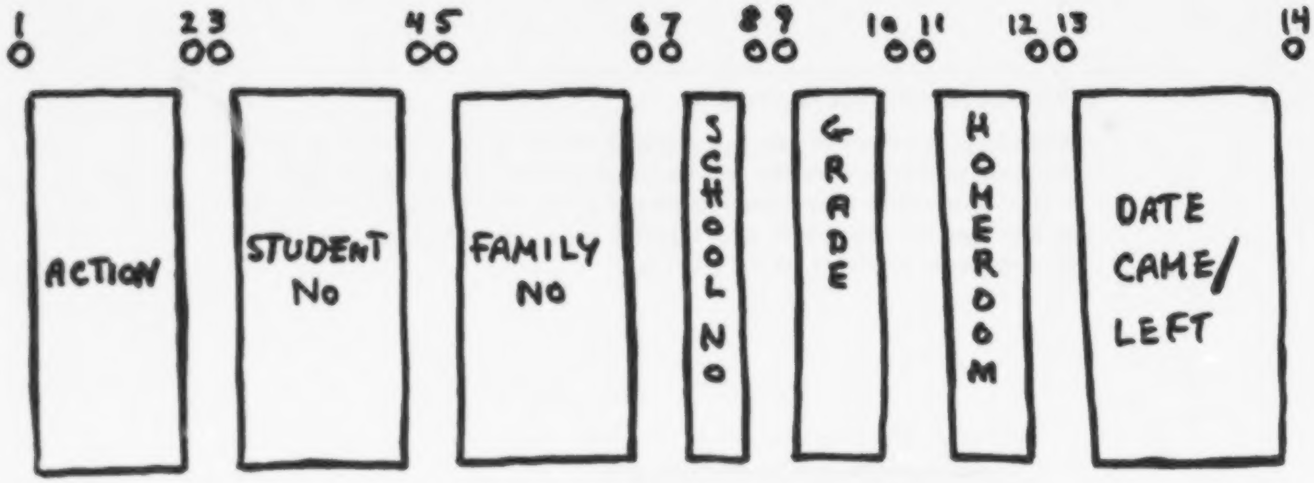


Figure 3.3 Sample Second Draft

FINAL DRAFT

The second draft merely outlines grid locations. It contains none of the detail that will be required by NCS to typeset and compose the form successfully. The steps for the final draft are as follows:

Step 1: First, on a fresh layout sheet, pencil in the exact outlines of the grids.
Step 2: The lines which will go inside each grid are drawn exactly where desired.
Step 3: Grid headings are added.
Step 4: Response circles and the response designators are placed. Some will have the response choices listed with a circle beside each. Others will have some unique characters to represent individual responses and these are shown exactly as desired. Standard alpha or numeric responses may be indicated in one column and then marked to indicate that they repeat. This type of grid is so common in OMR forms that the NCS forms personnel will automatically provide a complete grid.
Step 5: The drawing is now complete. Other miscellaneous features may be added. For example, if a corner cut is desired, that is marked on the mock-up.

Shading of alternate columns is desired to make it easier for the respondent to mark each column. We suggest using a colored marking pen of the type used to highlight passages in textbooks or notes. Do not mark the actual mock-up. Since the markers are usually indelible, it is a good idea to make a photocopy of the original and then mark the copy. If shading changes are made, the original mock-up is still usable. Various percentage values of shading and even reverse-type areas can each be marked with different colors. Just make sure you provide a key to color significance.

FORMS DESIGN HINT: Text

When large amounts of text are required on the form, it would be quite time consuming to write the text on the mock-up itself. In such cases, it is more convenient to indicate the general layout of the type on the mock-up and type the actual text on a separate page. Be sure to indicate where the copy must be placed on the mock-up.

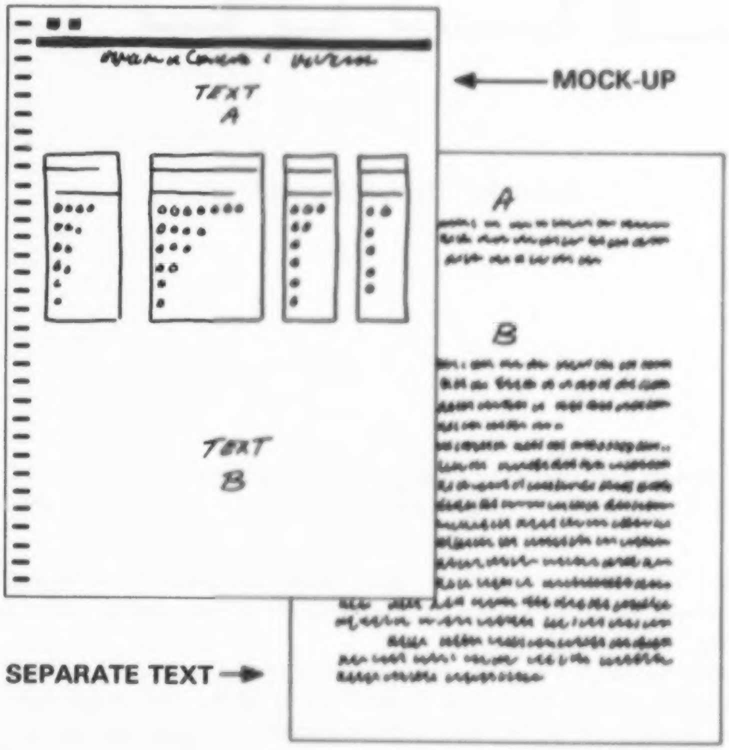


Figure 3.4 Text Indicated on Separate Sheet

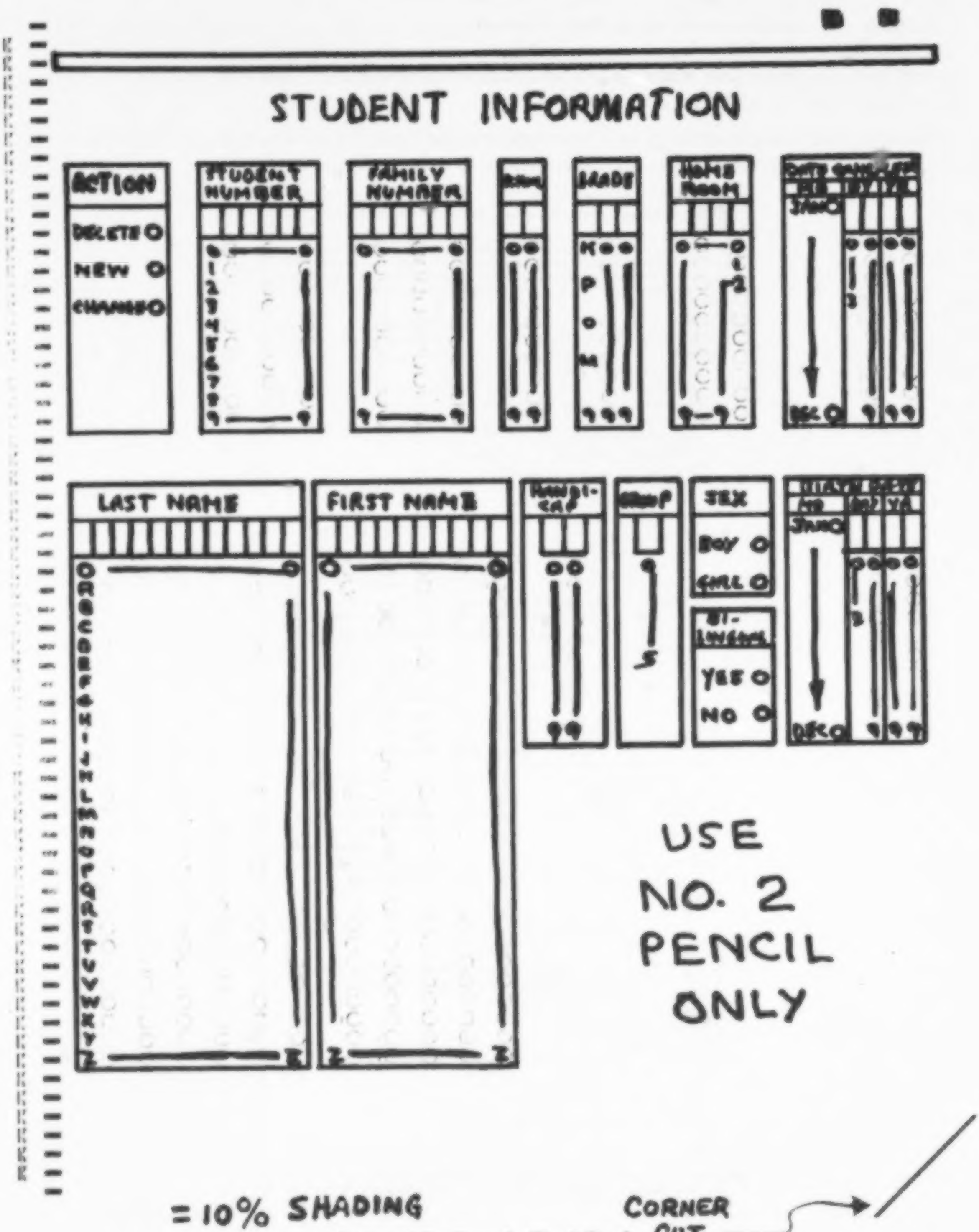
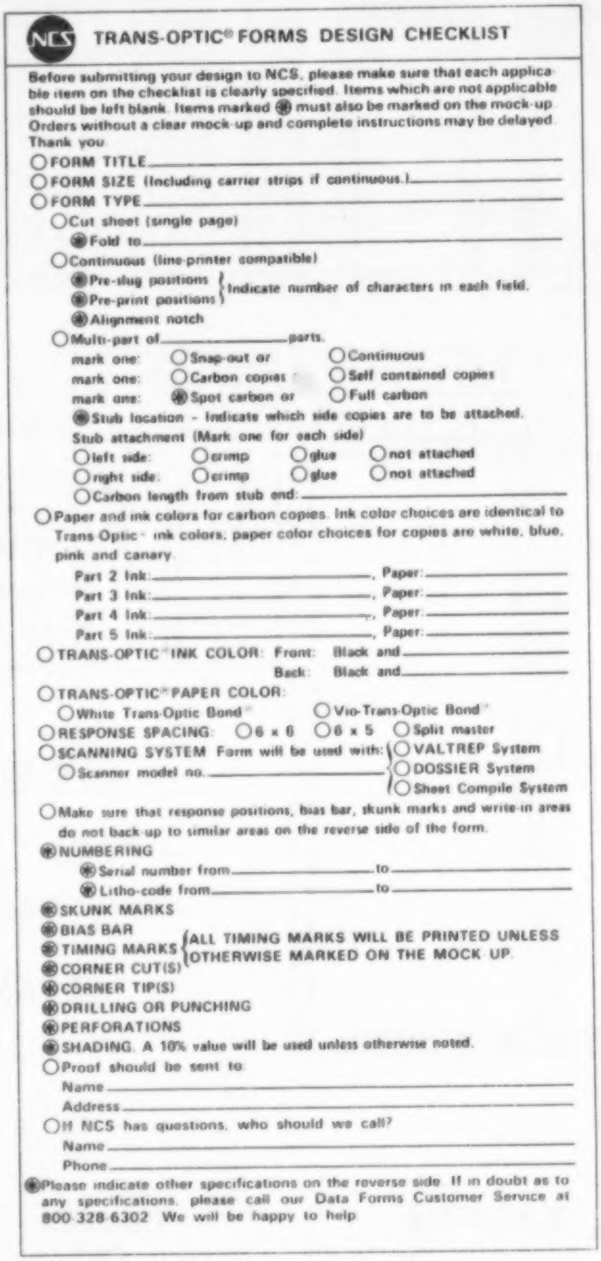

STUDENT INFORMATION
ACTION
DELETE
NEW
CHANGE
STUDENT NUMBER
FAMILY NUMBER
GRADE
HOME ROOM
MO
DY
YR
JAN
DEC
LAST NAME
FIRST NAME
HANDI-CAP
GROUP
SEX
BOY
GIRL
BI-LINGUAL
YES
NO
USE NO. 2 PENCIL ONLY
= 10% SHADING
CORNER CUT

Figure 3.5 Sample Final Draft

PROCEDURE CHECKLIST

When the mock-up is complete, the form should be checked against specifications a final time. Also there is a checklist on the layout sheet to remind you of all typical forms specifications. This checklist is not intended to be all encompassing; it covers only the most common specifications. It will help you make your mock-up and specification complete and it will help NCS produce a form that is exactly what you wish.

After users and other involved people have approved the final design, it is ready to be mailed to NCS/Data Forms Customer Service for composition and printing.



NCS TRANS-OPTIC® FORMS DESIGN CHECKLIST

Before submitting your design to NCS, please make sure that each applicable item on the checklist is clearly specified. Items which are not applicable should be left blank. Items marked ● must also be marked on the mock-up. Orders without a clear mock-up and complete instructions may be delayed. Thank you.

○ FORM TITLE ____________________
○ FORM SIZE (Including carrier strips if continuous.) ____________________
○ FORM TYPE ____________________
  ○ Cut sheet (single page)
    ● Fold to ____________________
  ○ Continuous (line-printer compatible)
    ● Pre-slug positions } Indicate number of characters in each field.
    ● Pre-print positions }
    ● Alignment notch
  ○ Multi-part of __________ parts.
    mark one: ○ Snap-out or ○ Continuous
    mark one: ○ Carbon copies ○ Self contained copies
    mark one: ● Spot carbon or ○ Full carbon
    ● Stub location - Indicate which side copies are to be attached.
    Stub attachment (Mark one for each side)
    ○ left side: ○ crimp ○ glue ○ not attached
    ○ right side: ○ crimp ○ glue ○ not attached
    ○ Carbon length from stub end: ____________________
○ Paper and ink colors for carbon copies. Ink color choices are identical to Trans-Optic™ ink colors; paper color choices for copies are white, blue, pink and canary.
    Part 2 Ink: ____________________, Paper: __________
    Part 3 Ink: ____________________, Paper: __________
    Part 4 Ink: ____________________, Paper: __________
    Part 5 Ink: ____________________, Paper: __________
○ TRANS-OPTIC™ INK COLOR: Front: Black and __________
    Back: Black and __________
○ TRANS-OPTIC™ PAPER COLOR:
  ○ White Trans-Optic Bond™ ○ Vio-Trans-Optic Bond™
○ RESPONSE SPACING: ○ 6 x 6 ○ 6 x 5 ○ Split master
○ SCANNING SYSTEM Form will be used with: { ○ VALTREP System
  ○ Scanner model no. __________ { ○ DOSSIER System
    { ○ Sheet Compile System
○ Make sure that response positions, bias bar, skunk marks and write-in areas do not back up to similar areas on the reverse side of the form.
● NUMBERING
  ● Serial number from __________ to __________
  ● Litho-code from __________ to __________
● SKUNK MARKS
● BIAS BAR
● TIMING MARKS { ALL TIMING MARKS WILL BE PRINTED UNLESS OTHERWISE MARKED ON THE MOCK UP.
● CORNER CUT(S)
● CORNER TIP(S)
● DRILLING OR PUNCHING
● PERFORATIONS
● SHADING. A 10% value will be used unless otherwise noted.
○ Proof should be sent to:
  Name ____________________
  Address ____________________
○ If NCS has questions, who should we call?
  Name ____________________
  Phone ____________________
● Please indicate other specifications on the reverse side. If in doubt as to any specifications, please call our Data Forms Customer Service at 800-328-6302. We will be happy to help.

Figure 3.6 Procedure Checklist

PROOFREADING

The end product of NCS typesetting and composition is a proof, which is a blue and white photographic print of the completed form. The purpose of the proof is to show you exactly how the form will look. It is your responsibility to check that the form is done exactly the way you want. If there are minor errors (such as typographical errors) or changes to be made, make the corrections directly on the proof. If the changes are at all major, such as rearranging grid positions or rewording entire bodies of text, the changes should be typed out on a separate sheet or redrawn on a fresh layout sheet.

Before returning the proof to NCS, you MUST sign it and indicate what category the proof is:

OK
OK with Corrections
Rejected

If you indicate OK, NCS will go ahead with the printing of the form. If you indicate OK with Corrections, NCS will make the small corrections, send you a confirming proof, and print the form. If you have indicated that the proof is Rejected (that is, it needs many major changes), NCS will make the changes and send you a new proof for your approval.

Keep in mind that while NCS will always take responsibility for the basic scannability of the form, you, the customer are responsible for the form design once you have signed your approval on the proof.

CUSTOMER PROVIDES CAMERA-READY COPY

If desired, a customer may supply "camera-ready copy" for development purposes. Since there are many defined conditions which must be met, contact NCS for specifications before starting forms development.

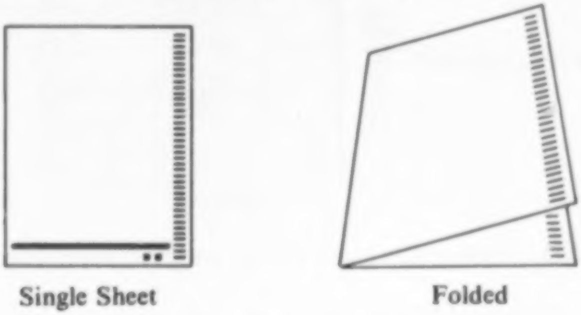
TYPES OF FORMS

Optical Mark Reading has been applied to a tremendous number of data entry needs. OMR forms applications include grade reporting, course selection, election ballots, vehicle registration, payroll deductions, retail inventory, service reports, and water meter reading, to name just a few. Different applications require different types of forms. A grade reporting form will have very different requirements than an election ballot. The NCS Applications Manual (NCS part no. 202-147-443) contains examples and descriptions of more than 50 different applications. We hope these examples will stimulate development of new applications and design ideas.

NCS scannable documents are manufactured in four basic formats: cut sheets, continuous, saddle stitched booklets, and multi-part forms. Each format and its specifications are discussed below.

CUT SHEETS

Cut sheets are usually cut to size during printing. They may be single sheets or folded.


Single Sheet

Folded

Figure 4.1 Cut Sheet Forms

CONTINUOUS FORMS

Continuous forms are designed to be run through a computer line printer prior to being given to the respondent. Some scanner-readable information, such as respondent identification, is printed. The respondent then marks the form and returns it to the user to be scanned. For this reason, such forms are sometimes called "turnaround documents".

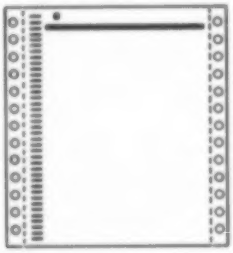


Figure 4.2 Continuous Forms

Continuous forms are manufactured from a continuous web of paper but are not cut into units. Each form is separated by a perforation where it can be torn apart after it has been run through a line printer.

In addition, continuous forms have a perforated strip on each side called "carrier strips" or "pin-feed strips" that enable the line printer to transport the paper during preprinting and preslugging.

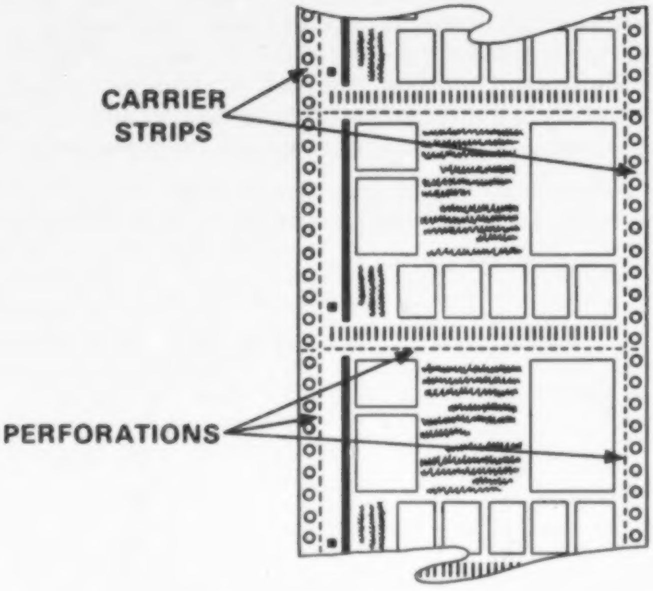


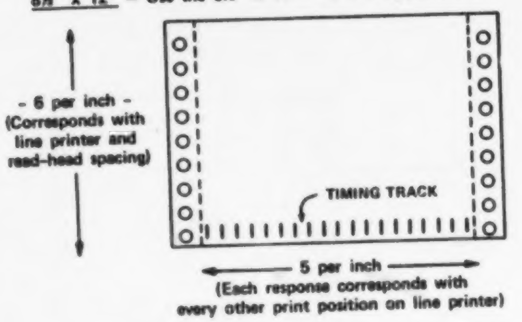
Figure 4.3 Continuous Form Carrier Strips and Perforations

Format for Continuous Forms

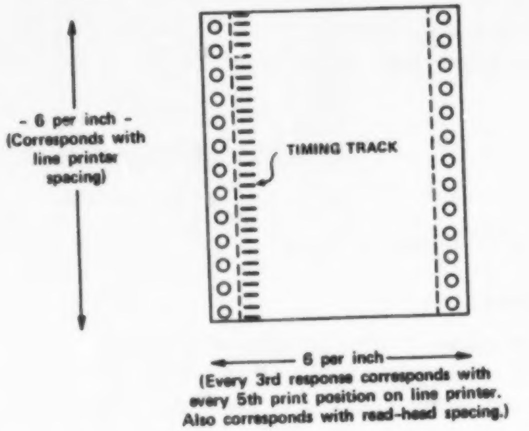
Line printer spacing is typically 6 lines per inch vertically and 10 characters per inch horizontally (with 132 characters total), while forms are either 6 x 6 or 6 x 5. Therefore, the forms designer must take particular care to ensure that each continuous form is line printer compatible, scanner compatible, and printing press compatible.

Following are diagrams of some of the most common continuous form formats to show how they are set up for line printer compatibility.

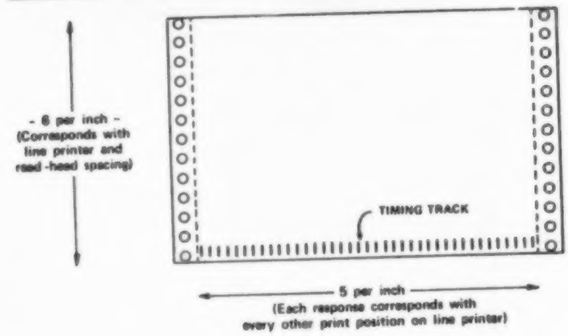
8½" x 12" – Use the 8½" x 11" – 6 x 5 layout sheet


- 6 per inch -
(Corresponds with
line printer and
read-head spacing)
TIMING TRACK
5 per inch
(Each response corresponds with
every other print position on line printer)

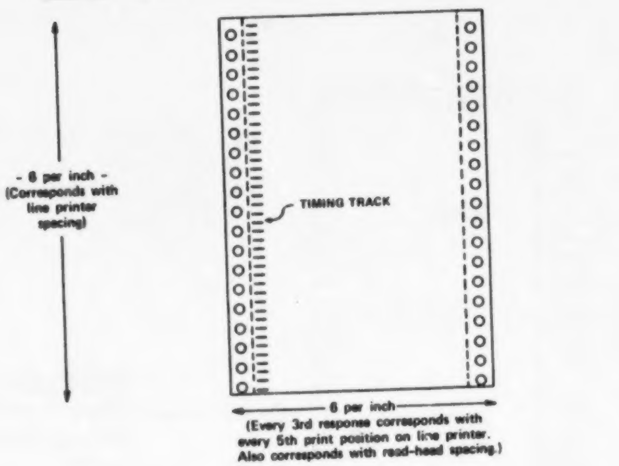
9½" x 11" – Use the 8½" x 11" – 6 x 6 layout sheet


- 6 per inch -
(Corresponds with
line printer
spacing)
TIMING TRACK
6 per inch
(Every 3rd response corresponds with
every 5th print position on line printer.
Also corresponds with read-head spacing.)

11" x 17-7/8" – Use the 11" x 17" – 6 x 5 layout sheet


- 6 per inch -
(Corresponds with
line printer and
read-head spacing)
TIMING TRACK
5 per inch
(Each response corresponds with
every other print position on line printer)

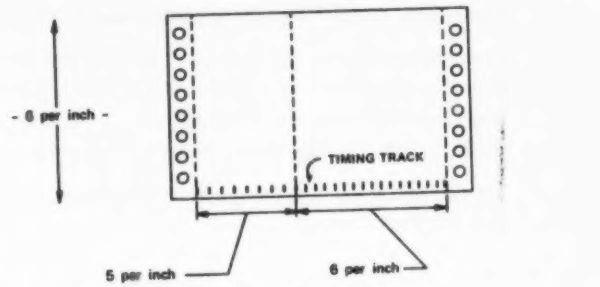
12" x 17" – Use the 11" x 17" – 6 x 6 layout sheet


- 6 per inch -
(Corresponds with
line printer
spacing)
TIMING TRACK
6 per inch
(Every 3rd response corresponds with
every 5th print position on line printer.
Also corresponds with read-head spacing.)

Special Designs

It is possible, on the 8½" x 12" and the 11" x 17-7/8" documents, to have a portion of the form 6 x 5 and the remainder 6 x 6. The important thing to remember here is that you must remain 6 per inch in the direction of the read-head and line printer spacing.

EXAMPLE


- 6 per inch -
TIMING TRACK
5 per inch
6 per inch

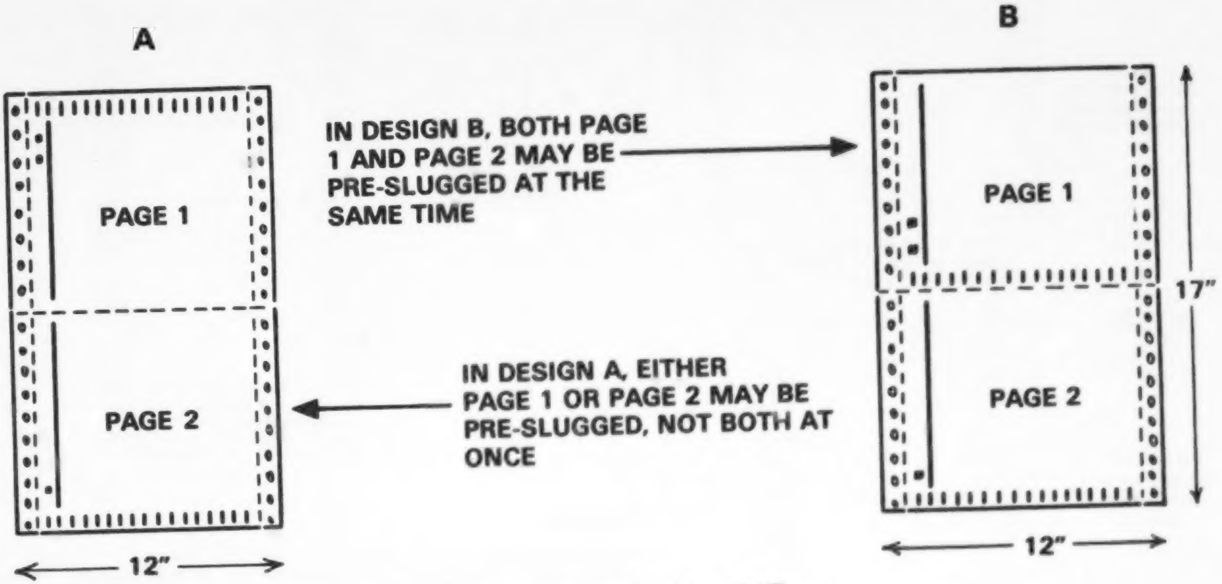
NOTES:
1. The above approach must be limited to one splice.
2. Any 5 per inch (or 6 per inch) sections must run along the entire height.
3. When designing a non-standard continuous form, splice two appropriate mock-up sheets into one before starting layout.

Figure 4.4 Standard Continuous Form Formats

Designing 12" x 17" Continuous Forms for Preslugging

12" x 17" continous forms may be arranged in two possible formats for preslugging. Design A in Figure 4.5 has the timing tracks at each 12" side. With this format, there is an extra space between the pages that throws off the 6 per inch spacing of the bubbles between page one and two. This means that when the printer has preslugged page one and spaces down to page two, that it will no longer be aligned with the bubbles on page two. One page may be preslugged and preprinted. The second may be preprinted only.

Design B, however, has the timing marks for page one next to the center of the 12" x 17" sheet and has eliminated the extra space. The line printer then can space directly down from page one and preslug page two in one pass.



IN DESIGN B, BOTH PAGE 1 AND PAGE 2 MAY BE PRE-SLUGGED AT THE SAME TIME

IN DESIGN A, EITHER PAGE 1 OR PAGE 2 MAY BE PRE-SLUGGED, NOT BOTH AT ONCE

Figure 4.5 Preslugging 12" x 17" Forms

Designing 4-1/4" Height Continuous Forms for Preslugging

Continuous forms with 4-1/4" height present a unique problem. If they are printed at exactly 4-1/4", each form is scannable but only every other form is line printer compatible. Response positions are spaced in increments of sixths from one form to the next and so are compatible with the vertical spacing of the line printer.

To be properly aligned, alternate forms must be staggered in size, alternating 4-1/3", 4-1/6", 4-1/3", etc.

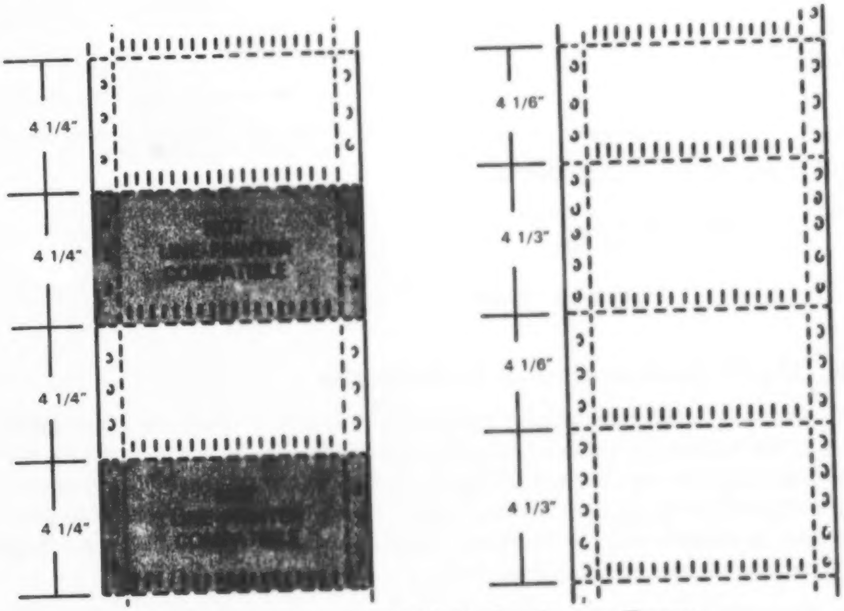
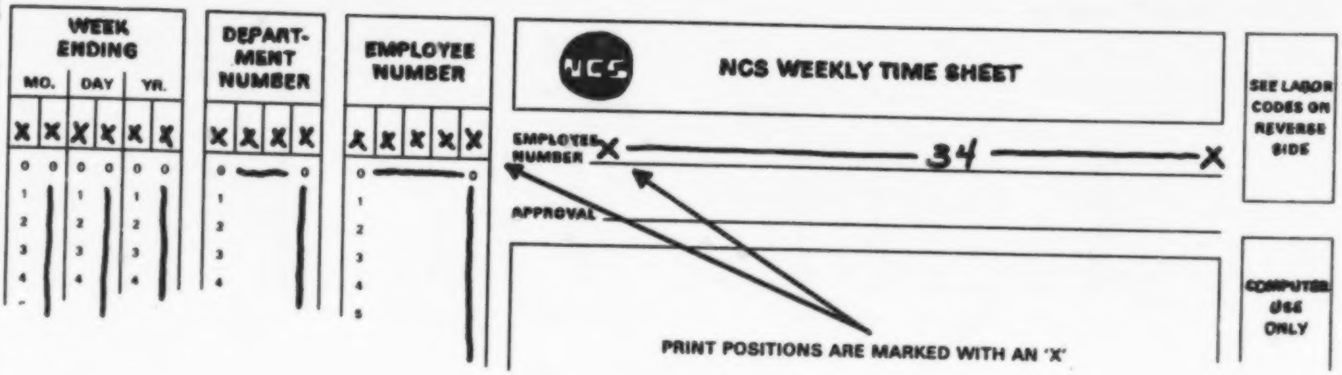


Figure 4.6 4-1/4" Height Continuous Forms

It is very important to understand that because of the uneven form height, these forms may not be mechanically burst apart. They must be separated by hand.

Indicating Line Printing Areas

To compose and typeset line printer compatible forms properly, NCS must know how many characters and which response positions you intend to line print. The standard way of indicating this is to print a series of X's to show line print areas. Since your mock-up will be done in pencil, it is helpful to mark each X in a contrasting color such as a red pencil.


WEEK ENDING
MO.
DAY
YR.
DEPART-MENT NUMBER
EMPLOYEE NUMBER
NCS
NCS WEEKLY TIME SHEET
EMPLOYEE NUMBER
34
APPROVAL
SEE LABOR CODES ON REVERSE SIDE
COMPUTER USE ONLY

PRINT POSITIONS ARE MARKED WITH AN 'X'

Figure 4.7 Line Printer Mock-up

BOOKLETS

Scannable booklets provide a means to have very large amounts of machine-readable information in a small package. They are particularly applicable in surveys or tests where it is desirable to have text and responses on the same page.

Booklets are 11 x 17 inch cut sheets that are collated together, stapled, and then folded into booklet form. Prior to processing, the pages must be cut apart at the fold so that each page is scanned separately. Your NCS Forms Customer Service Representative can assist you in obtaining the booklet cutting equipment necessary to do this. The critical guide edge of the form is always on the outside. NCS can produce booklets from 4 pages (one 11" x 17" sheet) to 52 pages (thirteen 11" x 17" sheets).

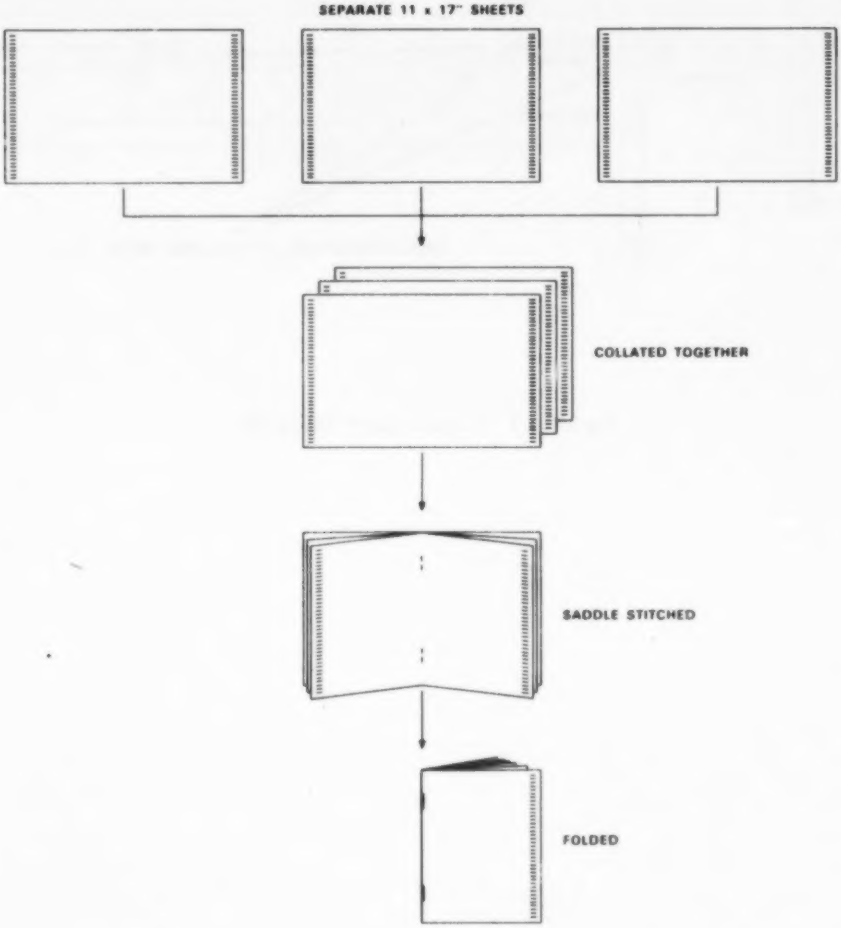


Figure 4.8 Production of Booklets

Booklet design is similar to other forms design. There are, however, some special considerations you must be aware of before you do a booklet design.

1. The timing track and critical edge must always be on the outside edge because the spine of the booklet will be cut off prior to scanner processing.
2. Orientation of skunk marks, bias bar, and timing marks should be the same for each page of a booklet.
3. As with any form, each booklet page must have a unique skunk mark assigned to it. It is sometimes helpful to assign the skunks in a systematic way that will identify individual pages and individual booklets. The usual way to do this is to assign a series of skunk mark positions that consistently indicate page sequence in the booklet, regardless of which booklet it happens to be. A separate series off skunk mark positions would identify each booklet. These positions would be identical within a booklet, but would vary from one booklet to the next.

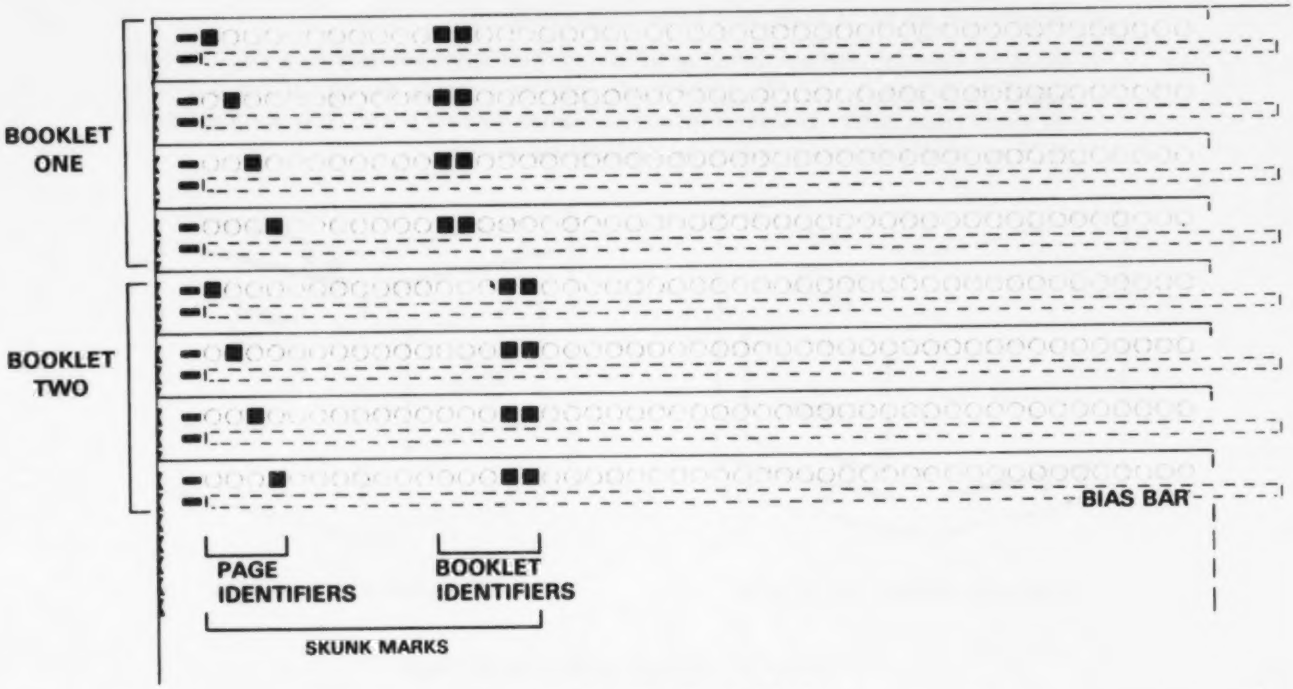


Figure 4.9 Booklet Skunk Marks

4. It is important to have some kind of identification system to tie together the pages of a booklet during scanning. In addition to skunk marks, there are two ways to handle this:

   a)Pinhole Numbers
   Pinhole numbering involves punching a six digit number through all the pages of the booklet. It is not machine-readable but does allow the pages to be visually gathered together if they become separated. The largest booklet that can be pinhole numbered is 24 pages (6 signatures). Pinholes can not be in areas with response positions on either side of the paper.

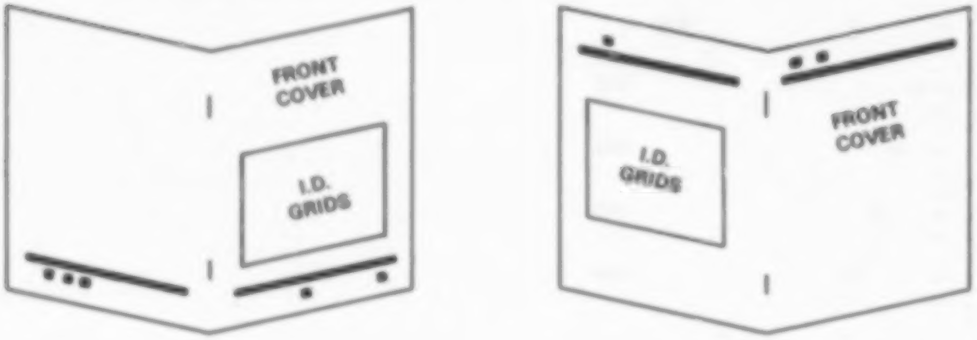
b)Write-in identification on each page

These are areas on each odd (or even) numbered page for the respondents to write their names or ID numbers; again allowing scattered sheets to be visually gathered.

5. When processing booklets, it is often desirable to perform various edit checks, particularly on the accuracy of the identification information. To do this properly, the booklet must be designed so that the identification page is the first to be scanned by the system. This way, if some critical biographical information is incorrect, the entire booklet can be selected out, either by a select stacker or by stopping the scanner.

   Therefore, the identification page should be either the outside front cover or the outside back cover. Since skunk marks are usually placed at the leading edge of the form, skunk marks are placed at the bottom of the page when identification is on the front cover and at the top of the page when identification is on the back cover. This allows the correct page to be fed into the scanner first. If the identification page is selected out because of errors, the data pages which follow it may also be selected out.

6. Booklets of up to 24 pages may be pinhole numbered.
7. Booklets may be serial numbered or litho-code numbered but only on a single 11 x 17" signature (4 pages). NOTE: Litho-Code requires a special set-up. If this is desired, we must know **before any** development, not after the first proof. It is not possible for NCS to print matching numbers on multiple signatures.



LEAD EDGE AT BOTTOM OF PAGE

LEAD EDGE AT TOP OF PAGE

Figure 4.10 Design of Booklet ID Page

FORMS DESIGN HINT: Booklets

While booklet design is really not very different from other forms design, it often seems more difficult because of the number of pages involved. Planning is the key to success. You must plan what will go on each page.

What do you do if your design just fits comfortably on 9 pages and you would rather print an 8 page booklet than a 12 page booklet? Resist temptation. Unless some copy can be removed or the design can be worked out to fit 8 pages easily, you will be better off with the 12 pages. The respondents will have an easier time marking the answers and the quality of the data you get will show it.

Booklets are put together in increments of 4 pages (4, 8, 12, etc.) Often the number of pages you require will not be an increment of 4. You may want to use the extra space to spread out some areas that are a little cramped or maybe you can put together some snappy graphics for the cover instead of diving into the response areas right away. You can also leave blank pages to fill out the booklet so that it is a multiple of 4. Don't let this bother you. There is plenty of printed material that has a blank page or two.

MULTI-PART SETS

Multi-Part Sets are forms with copies and carbon attached. There are two types:

-Cut sets ("snap-sets")
-Continuous sets ("snapouts")

Cut sets (snap-sets) are usually made up of scannable top sheet and from one to five other parts which are glued together at a stub attached to one side or end. Each copy is perforated at the stub. Copies are made in two ways: Carbons can be interleaved between parts or the copies themselves can be printed on a "self-acting" or "carbonless-copy" paper.

Continuous sets (snapouts) work in the same way, but have additional carrier strips for transport through the line printer.

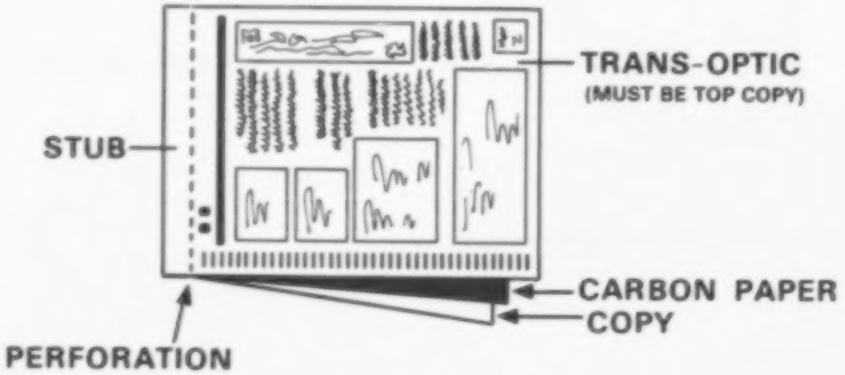


Figure 4.11 Cut Set

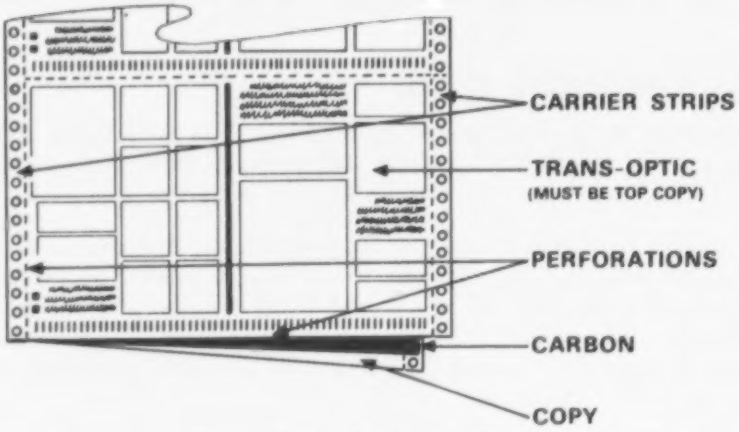


Figure 4.12 Continuous Set

Multi-Part specifications are as follows:

1. Parts of the set are attached at a stub where they are glued for cut sets and either glued or crimped for continuous sets.

   If glued, only one side should be glued. Gluing is sometimes necessary if there is to be extensive handling before detaching and scanning. Crimping is preferable when ease of separation is desired, such as when forms are to be decollated after printing or on one side of a continuous set with the other side glued so that it functions as a snap-out after it is printed and burst apart.

2. Cut set stubs are usually 5/8" wide and may be on either the short or the long side of the form. Continuous set stubs are 1/2" wide and correspond to the carrier strips. One side of the continuous set is usually crimped for easier separation, especially if the continuous forms are burst apart and then used as snap-sets after they have been line printed.

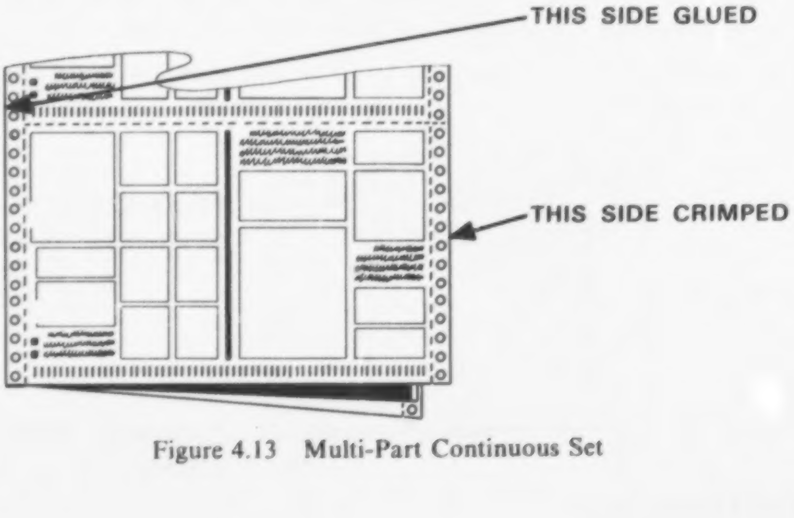
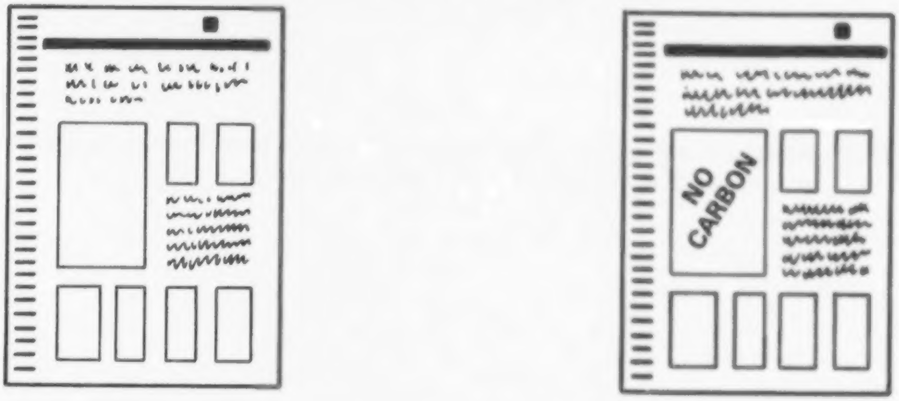


Figure 4.13 Multi-Part Continuous Set

3. Copies can be made in two ways: Carbons can be interleaved between parts or the copies themselves can be printed on self-contained or "NCR" (no carbon required) type paper. NCS recommends using carbon paper because it is less expensive, more available, and produces a sharper image than self-acting paper. Self-acting paper is not recommended when there are more than 2 copies in a set.
4. When possible, the carbon paper will be left shorter than the original and copies so that there is a grasping margin to allow easier separation.
5. Spot carbon is a means of deleting carbon from a specific area of a snap-set so that marks made there do not mark through to the copies from the original. To indicate where you want carbon, make a photo copy of your mock-up and mark the areas which will copy and those that will not. See Figure 4.14.



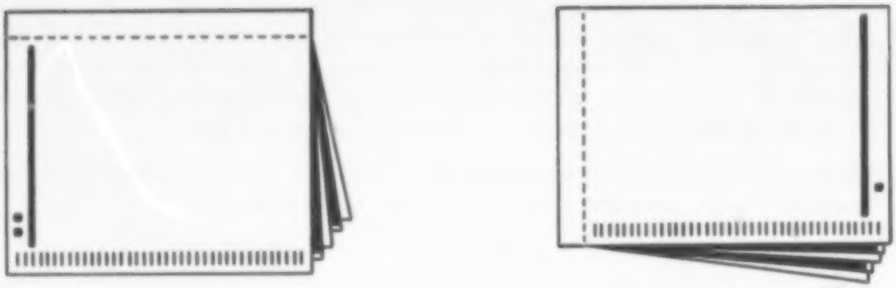
ORIGINAL

COPY MARKED TO SHOW CARBON AREA

Figure 4.14 Indicating Spot Carbons

6. Maximum width of multi-part forms is 17 1/8", including the 5/8" stub. (Form is 16 1/2"). Maximum width of continuous sets is 17 5/8", including 1/2" carrier strips each side. (Form is 16 5/8").
7. Copies are available on a 12 or 15 pound bond paper. Available paper colors are white, blue, pink, and canary. Ink colors for the copies are identical to the choices for OMR forms.

   It is not advisable to use blue carbon with a blue form (body copy and response positions) because there is not enough contrast between the form and the **marked** response position. This also applies when using black carbon with black type.
8. Marginal words may be printed on the form to identify copies such as "Data Processing Copy", "Office Copy", and "Student Copy".
9. Stub location is at the designer's discretion. However, we urge that it be located adjacent to the trailing or outside edge to minimize problems caused by sets being improperly torn apart. The respondent may accidentally rip the skunk marks if the stub is at the leading or guide edge.



Stub at Outside Edge

Stub at Trailing Edge

Figure 4.15 Snap-Sets

NOTE: Because of the unique requirements of multiple part forms, it is always a good idea to check with NCS prior to final forms design.

FORM SIZES

The sizes of forms may also vary. In deciding on a form size, you should consider what size can be processed on your model of scanner (See Chapter 10) and what size can be printed by NCS.

Form sizes printed by NCS:

Height	Minimum Width	Maximum Width
3-2/3"	7-1/2"	17-7/8"*
4-1/4"**	7-1/2"	17-7/8"*
5-1/2"	7-1/2"	17-7/8"*
5-2/3"	7-1/2"	17-7/8"*
8-1/2"	3-2/3"	17-7/8"*
11"	3-2/3"	17-7/8"*
17"	3-2/3"	17-7/8"*

Printed sizes always include stubs, carrier strips, receipts, etc.

* 17 5/8" if multi-part continuous sets, 17 1/8" if multi-part cut sets

** 4-1/4" height is impossible with continuous form. Individual forms alternate 4-1/3, 4-1/6, 4-1/3, etc. in height.

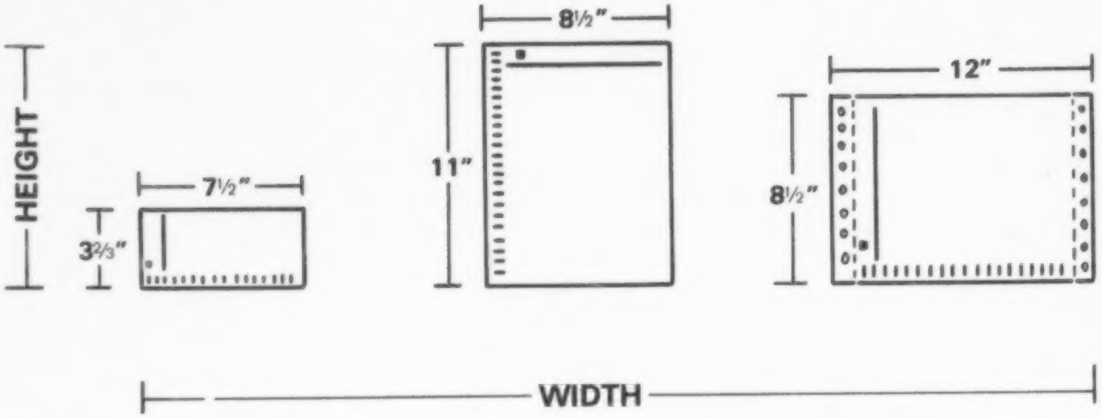


Figure 4.16 Width and Length of Typical Form Sizes

If a form is to be produced in a continuous or snap-set format, the scanning size of the form remains the same as that of a cut sheet format. However, carrier strips or stub will have to be added to the overall width of the printed format. For continuous forms with a width of 7-1/2" up to 16-3/4", add 1/2" to each side. For forms wider than 16-3/4", add 7/16" to each side. For snap-sets, a 5/8" stub is needed to glue the sheets into a set.

EXAMPLE:

8-1/2" x 11" in continuous format would be 8-1/2" x 12", or 9-1/2" x 11", depending upon carrier strip location. (Also applies for multi-part continuous.)

11" x 17" in a continuous format would be 11" x 17-7/8", or 12" x 17", depending upon carrier strip location. (Also applies for multi-part continuous.)

8-1/2" x 11" in a snap-set format would be 8-1/2" x 11-5/8", or 9-1/8" x 11", depending upon stub location.

APPENDIX F

Preceding page blank

The NCS price list reproduced on the following four pages is provided only as an indication of what costs for optically read forms might be. It is not definitive and is in no way binding to National Computer Systems, Colorado State University, or the Environmental Protection Agency.

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Trans-Optic

Custom Forms Price List

4401 WEST 76TH ST., MINNEAPOLIS, MN. 55435
612-830-7600

EFFECTIVE JANUARY 1, 1982

This price list covers the development, printing and scheduling of all custom Trans-Optic® forms (both new orders and reprints) which are to be scanned on NCS equipment. Your data form is a critical element in your general scanning operation. The NCS combined hardware and forms offering represent the true systems answer to your scanning needs.

Prices listed in this folder are presented to assist you in determining your overall costs and to help in planning your budget. Prices may be subject to reduction based upon the per order volume, forms sizes, color combinations and delivery schedule requirements.

Please direct written inquiries, purchase orders and other materials to your local Customer Service Representative. For immediate assistance call Forms Customer Service at:

Minneapolis, MN	800-328-6302 or 612-830-7610
Lancaster, PA	800-233-0143 or 717-394-7196
Owatonna, MN	800-533-0518 or 507-451-5137

We will respond quickly with a verbal and/or written proposal. Thank you for the opportunity to serve your needs and your confidence in NCS and our products.

NOTE: Standardized Test Sheets and General Purpose Answer Sheets are carried in inventory and listed on separate price sheets.

You may place an order or request information by writing or calling NCS Forms Customer Service.

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NATIONAL
COMPUTER
SYSTEMS
FORMS DIVISION

COMPOSITION/DEVELOPMENT:

	8½ X 11 9½ X 11 or 8½ X 12		11 X 17 12 X 17 or 11 X 17⅞	
	ONE-SIDED	TWO-SIDED	ONE-SIDED	TWO-SIDED
MOCK-UP (LAYOUT)	$ 75	$125	$100	$200
COMPOSITION (INCLUDES ONE PROOF)	$230	$365	$335	$590
SHADING	$ 25	$ 35	$ 30	$ 45
ADDITIONAL PROOFS	$ 15	$ 20	$ 20	$ 30
REVERSE PRINTING	$ 25	$ 35	$ 30	$ 45
SPLIT MASTER	$ 25	$ 35	$ 35	$ 45

FORMS REQUIRING ADDITIONAL COLOR WILL BE QUOTED UPON REQUEST (SEE "ADDITIONAL COLORS" ON PAGE FOUR.).

ALTERATIONS – PRICE BASED UPON EXTENT OF ALTERATION.

ALL ART WORK, NEGATIVES, PLATES AND OTHER ITEMS PREPARED BY NCS SHALL REMAIN THE PROPERTY OF NCS.

PRICES FOR OTHER SPECIAL DEVELOPMENT WORK WILL BE QUOTED UPON REQUEST.

NOTE: ALL PRICES PER THOUSAND FORMS BASED UPON A MAXIMUM OF TWO COLORS PER SIDE (ONE OF THE TWO COLORS ON EACH SIDE BEING BLACK)

	CUT SHEETS		CONTINUOUS FORMS			
QUANTITY	8½ X 11	11 X 17	9½ X 11	8½ X 12	11 X 17⅞	12 X 17
250,000	20.45	36.05	22.15	24.25	35.20	44.75
200,000	21.35	37.80	22.65	25.20	36.40	46.25
150,000	22.05	39.80	23.35	26.20	37.90	48.15
100,000	23.40	43.25	24.40	27.35	39.35	49.65
90,000	23.95	44.85	25.30	28.25	40.55	50.75
80,000	24.50	46.50	26.05	28.80	41.55	51.45
70,000	25.30	48.10	27.35	29.80	43.65	53.15
60,000	25.55	49.65	28.75	30.25	44.85	53.90
50,000	26.00	51.10	30.20	31.60	46.45	54.65
40,000	28.20	54.95	32.80	33.55	49.00	56.90
30,000	30.80	57.50	36.60	37.70	50.90	62.55
20,000	37.40	61.50	46.15	46.15	61.50	71.35
10,000	49.30	75.20	60.95	60.95	90.15	95.55
5,000	73.90	108.00	96.65	96.65	142.10	142.10

ALL PRICES ARE F.O.B. SHIPPING POINT UNLESS QUOTED OTHERWISE. TERMS: NET 30 DAYS

CUT SHEETS:

The above prices include plates, printing, paper, folding and standard packaging. Special features such as numbering, special packaging, perforating, etc., will be quoted on an individual form basis. Quantities and sizes not addressed above will be quoted upon request.

CUT SHEET STANDARD PACKAGING

	QUANTITIES	
Forms Size	Inner Package	Outer Cartons
8-1/2 X 11	500	5,000
11 X 17	250	2,500

CONTINUOUS SHEETS:

The above prices include plates, printing, paper, perforating, line-hole punching, and continuous folding. Special features other than those listed in this paragraph will be quoted on an individual basis. Quantities and sizes not addressed above will be quoted upon request.

CONTINUOUS FORMS STANDARD PACKAGING

	QUANTITIES
Forms Size	Outer Cartons
9-1/2 X 11	2,500
8-1/2 X 12	2,500
11 X 17-7/8	1,500
12 X 17	1,500 or (1,250 if perf. at 8-1/2")

SHIPPING SCHEDULE:

MOCK UP – supplied by customer, or .... allow 1–2 weeks

DEVELOPMENT – includes type, paste-up, negative assembly and proof .... allow 3–4 weeks.
(Major revisions to proofs may result in two additional weeks lead time for processing.)

PRINTING – subject to approval of proof or receipt of reprint order,
up to 250,000 .... allow 2–3 weeks.
From 250,000 to 1,000,000 .... allow 3–4 weeks.
Greater quantities quoted on individual basis.

SHIPPING – When placing a purchase order, consider the estimated ship date and your required in-house date. Plan your method of transportation accordingly; i.e.: truck, parcel post, air freight, etc. Specify method on your P.O.

Our overall lead time reflects the seasonal nature of your forms requirements. The quickest turn-around time will be realized by placing orders from October through May. Orders placed in the remaining five months may result in longer lead times.

If you need faster service, please call for our best lead time estimate.

SPECIAL NOTES:

1. AVAILABLE PRICING DISCOUNTS

- You may also be eligible for a multiple order discount which is based on identical sizes and colors of forms. The exact discount will be quoted by your Customer Service Representative at time of order.
- Our 4 for 4 program in 1981 – take advantage of a 4% discount on the printing price of your forms order. To qualify, place your order at least four months prior to the requested ship date. This additional time allows us to gain plant efficiencies which we will pass along to our customers. We will ship and invoice upon completion of your order.

2. OTHER FORMS PRODUCTS

- This price sheet reflects only the most commonly purchased forms. NCS also manufactures booklets (several sheets stapled together) and multi-part sheets (which include carbons or self contained reproduction paper). The multi-part documents are produced in either a continuous or snap set format. Due to the specialized nature of these products they are not referenced individually. However, your Customer Service Representative will be happy to provide pricing quotes and assist with placing your order. NCS intends to meet all your scannable forms needs.
- NCS also manufactures standard one-part Green bar computer stock paper. Product specifications are as follows:

Description	Price per thousand
12" X 8-1/2" White Bond Green bar	$6.32
14-7/8" X 11" White Bond Green bar	$8.32

This product will be packaged 3000 per carton and will be shipped F.O.B. Owatonna, MN. There is a minimum order quantity of two cartons.

3. INFORMATION REQUIRED WHEN ORDERING

- Form Size
  - – In the case of continuous forms, state overall sizes before and after carrier strips are removed.
- Color Desired
- Quantities Desired
  - – Higher volume purchases reduce your per form costs.
- Special Features
  - – Corner cuts, litho-code, perforations, alignment notch, etc., see back page for details.
- Include Copy
  - – Mock-up, previously printed form, etc.
- Ship Date Desired
  - – Plan to receive your forms several weeks prior to distribution and use.
- Receiving Location(s)
- Purchase Orders
  - – Should contain all standard or quoted prices.

REFER TO PAGE 4 FOR SPECIAL AND STANDARD FEATURES

SPECIAL FEATURES: (Offered at an extra charge, please consult your Customer Service Representative for details. Also, for a more complete definition of features, please refer to your Forms Design Guide.)

- LITHO-CODING: A scanner readable numbering technique developed to identify two halves of a sheet too large to scan on systems other than a model 7015. Litho-Coding can also be used for special projects where machine readable identification numbers are required. Includes matching decimal numbers.
- DECIMAL NUMBERING: Available in vertical or horizontal format on most cut or continuous forms.
- CORNER CUTTING: This process is not required in the scanning operation but is often desired by users to assure forms are stacked properly prior to processing.
- ALIGNMENT NOTCH: 1/4 inch holes positioned over the perforation that separates the form from the carrier strip on continuous forms. The alignment notch serves the same purpose as corner cutting but has the advantage of being placed in one of several locations along the carrier strip. This service is free on continuous forms but there is a charge on cut sheets.
- NON-ST[illegible] PACKAGING: We welcome the opportunity to perform special handling, packaging, and shipping requirements to fill your special need.
- [illegible] The standard prices on page 2 cover the printing of forms with a maximum of one color (plus black) on each side of the form. Extra colors are available and will be quoted upon request.

STANDARD FEATURES:

- **HIGHLY TRAINED AND DEDICATED PERSONNEL:** The development and production of Trans-Optic® forms requires very sophisticated graphic arts equipment. However, it takes people, quality people, to monitor this equipment, and we are proud of our training procedures and employee dedication that result in the production of forms which are unequaled in the industry.

- **QUALITY CONTROL PROCEDURES:** We don't just talk quality, we produce it. Every phase of production, from the manufacturing of the paper to the shipping of finished products, is subjected to the highest standards of quality control. We see your forms the way your scanner sees them.

- **SCANNABLE PAPER:** All NCS scannable forms are printed on NCS Trans-Optic® Bond paper stock. This paper is manufactured exclusively for NCS and is monitored at the mill using NCS testing equipment. Forms printed on non-NCS paper have caused scanning inaccuracies and may result in unusable documents.
  Our registered Trans-Optic® trademark on your forms is a guarantee that the paper opacity and uniformity is within NCS system requirements.

- **GUARANTEE:** We guarantee our Trans-Optic® forms and back this guarantee with the knowledge necessary to respond effectively when a problem is encountered. We have highly skilled customer engineering personnel located throughout the United States who are available to help when needed.

APPENDIX G

The following pages appear in the Colorado Department of Health Mobile Sources Section report titled "Data Management for the AIR Program, July 1981 to December 1981" dated January 20, 1982. They describe the reports produced for the "blue system" for the AIR Program and contain samples of several of the reports.

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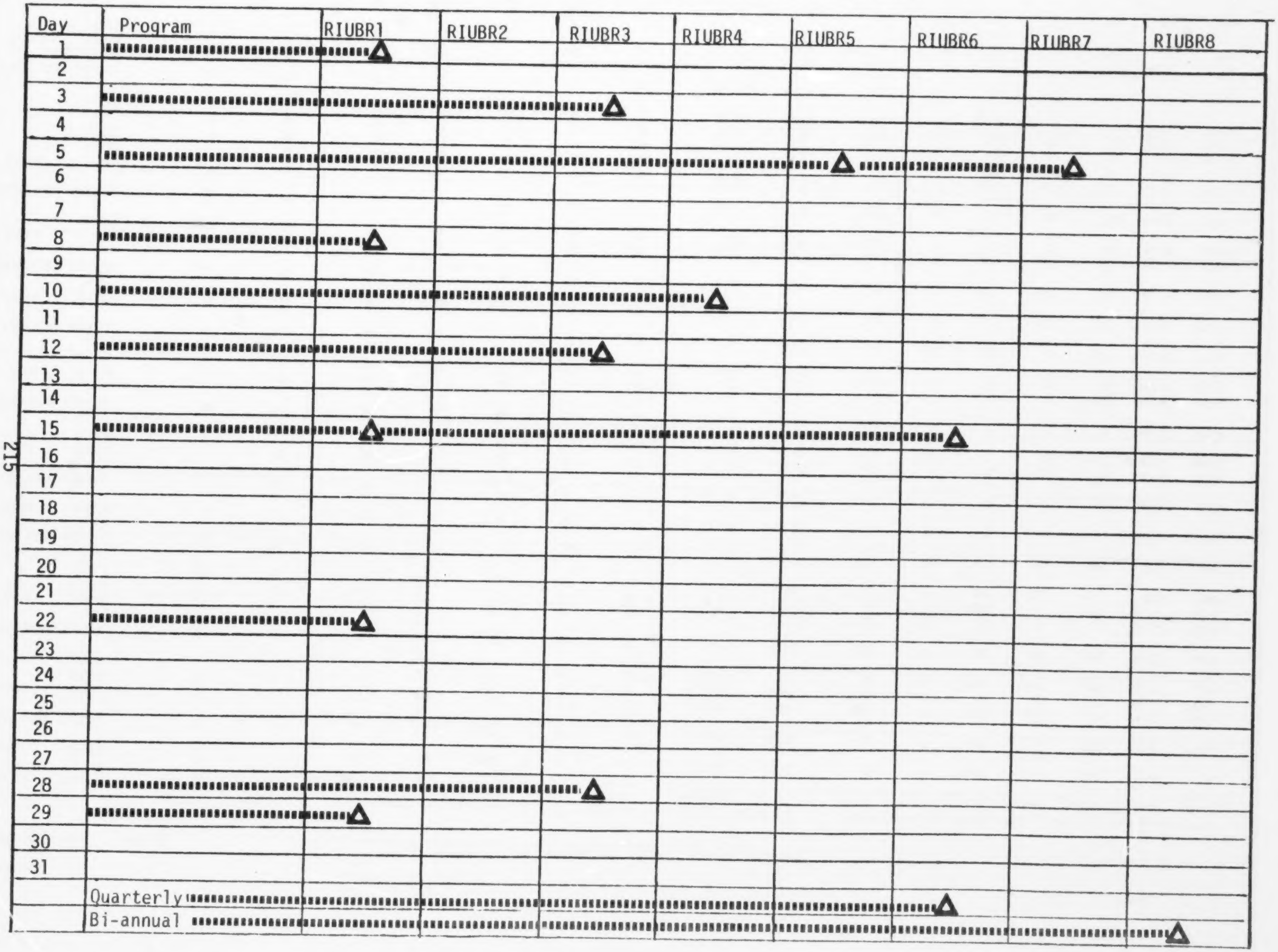
AIR PROGRAM DATA REPORTS

Program	Name	Due Dates	Language	Contents
RIUBR1	AIR-Error Report	Weekly	COBOL	Non-cumulative distribution by mechanic number within station number of: 1) Tests added 2) Number of errors 3) Distribution of error percentages over: a)make, b)vehicle license number, c) date, d) cost, e) number of cylinders 4) Average first test CO and HC readings 5) First test pass rate 6) First visual fail rate 7) First emissions fail rate 8) First test CO fail rate 9) First test HC fail rate 10) Final test fail rate 11) Final emissions fail rate
RIUBR2	Statistics on Tests by Station Number	Monthly	SPSS	Cumulative station number distribution of: 1) Total tests 2) Total retests 3) Test fail rate; and for CO and HC 4) Average first test readings 5) Average final test readings 6) Percentage reductions 7) Actual reductions
RIUBR3	Statistics on Tests by Model Year	Bi-monthly	SPSS	Cumulative model year distribution of: 1) Total tests 2) Total retests 3) Test fail rate; and for CO and HC 4) Average first test readings 5) Average final test readings 6) Percentage reductions 7) Actual reductions
RIUBR4	Pass/Fail Distribution Frequencies	Monthly	SPSS	1)Pass/fail counts for first and final test CO and HC 2)Frequency distributions for model year and CO and HC and final tests and reductions 3)Count and failure rate for first and final tests

AIR PROGRAM DATA REPORTS (continued)

Program	Name	Due Dates	Language	Contents
RIUBR5	AIR-Monthly Error Summary	Monthly	SPSS	Monthly summary of errors, CO and HC readings, and pass/fail rate distributions by mechanic number within station number (weekly error reports) showing number of errors in place of percentages and indicating which values lie outside of acceptable tolerances.
RIUBR6	Distribution by Make within Model Year	Monthly and Quarterly	SPSS	Cumulative and non-cumulative distribution by Make within model year for CO and HC each of: 1) Average first test readings 2) Average final test readings 3) First test to final test reductions 4) Percentage reductions
RIUBR7	Statistics on Tests by County	Monthly	SPSS	Cumulative model year distribution by County of: 1) Total tests 2) Total retests 3) Test fail rate; and for CO and HC each 4) Average first test readings 5) Average final test readings 6) Percentage reductions 7) Actual reductions
	As requested			1) Average costs for: a)inspection, b) adjustment 2) Pass/fail rate for "home adjust" vehicles 3) Number of voluntary repairs 4) True (as opposed to issued) numbers for vehicles a) Compliance b) Adjustment c) Denied

SCHEDULE OF AIR PROGRAM DATA REPORTS



R.IUBR1

COLORADO DEPARTMENT OF HEALTH

REPORT DATE 11/16/81

INSPECTION - MAINTENANCE WEEKLY ERROR REPORT

STN #	MECH #	RECS. ADDED	REC. ERRS.	** ERROR PERCENTAGE BY FIELD *** MAKE	LIC.	DATE	COST	#CYL	AVG. COUNTS X/CO	X/HC	*********** PASS/FAIL RATES *********** P/1	F/V	F/E1	F/CO	F/HC	F/2	F/E
1001	0741	1	1	0	0	100	0	0	0.5	600	0	0	100	0	100	N/A	N/A
STATION TOTAL		1	1	0	0	100	0	0	0.5	600	0	0	100	0	100	N/A	N/A
1003	0535	5	1	0	0	0	20	0	2.0	624	60	0	40	20	40	N/A	N/A
	2566	2	1	0	0	50	0	0	4.3	238	100	0	0	0	0	N/A	N/A
	2571	1	0	0	0	0	0	0	5.8	560	0	0	100	100	100	N/A	N/A
STATION TOTAL		8	2	0	0	13	13	0	3.0	519	63	0	38	25	38	N/A	N/A
1004	0964	2	0	0	0	0	0	0	0.7	125	100	0	0	0	0	N/A	N/A
	1559	1	0	0	0	0	0	0	3.1	140	0	0	100	0	100	N/A	N/A
	1562	2	0	0	0	0	0	0	4.8	505	50	0	50	50	50	50	50
STATION TOTAL		5	0	0	0	0	0	0	2.8	480	60	0	40	20	40	20	20
1006	1623	1	0	0	0	0	0	0	2.0	200	100	0	0	0	0	N/A	N/A
STATION TOTAL		1	0	0	0	0	0	0	2.0	200	100	0	0	0	0	N/A	N/A
1007	2354	2	0	0	0	0	0	0	1.9	200	100	0	0	0	0	N/A	N/A
	2356	1	0	0	0	0	0	0	4.0	900	100	0	0	0	0	N/A	N/A
STATION TOTAL		3	0	0	0	0	0	0	2.6	433	100	0	0	0	0	N/A	N/A
1008	2106	1	0	0	0	0	0	0	0.2	0	0	100	100	0	100	N/A	N/A
	2412	1	0	0	0	0	0	0	3.5	400	100	0	0	0	0	N/A	N/A
STATION TOTAL		2	0	0	0	0	0	0	1.9	200	50	50	50	0	50	N/A	N/A
1009	0686	2	0	0	0	0	0	0	4.3	90	0	0	100	50	50	N/A	N/A
STATION TOTAL		2	0	0	0	0	0	0	4.3	90	0	0	100	50	50	N/A	N/A
1013	0316	5	3	0	0	0	0	20	4.7	303	40	0	60	60	0	N/A	N/A
	0396	1	0	0	0	0	0	0	1.6	300	100	0	0	0	0	N/A	N/A
STATION TOTAL		6	3	0	0	0	0	17	4.2	303	50	0	50	50	0	N/A	N/A
1014	1523	1	1	0	100	0	0	0	8.0	0	0	0	100	100	100	N/A	N/A
	1596	1	0	0	0	0	0	0	7.6	700	0	0	100	100	0	N/A	N/A
	1682	4	0	0	0	0	0	0	0.9	144	100	25	0	0	0	N/A	N/A
	1685	2	0	0	0	0	0	0	4.5	273	50	0	50	50	0	N/A	N/A
	1940	1	0	0	0	0	0	0	3.2	200	100	0	0	0	0	N/A	N/A
STATION TOTAL		9	1	0	11	0	0	0	3.5	447	67	11	33	33	11	N/A	N/A
1015	1916	1	1	0	100	0	100	0	0.1	5	100	0	0	0	0	N/A	N/A
	1922	1	0	0	0	0	0	0	0.2	550	0	0	100	0	100	100	100
STATION TOTAL		2	1	0	50	0	50	0	0.2	778	50	0	50	0	50	50	50

KEY TO AIR - WEEKLY ERROR REPORT

COLUMN LABEL	DEFINITION
Stn #	License number of emission testing stations
Mech #	License number of emissions mechanic
Recs.Added	Total records completed by individual licensed emissions mechanic that have been edited by the Optiscan system and edited by the computer
Rec.Errs.	Number of records that were improperly marked or out of range for any edited field
Error Percentage by Field	(Next five columns) Make/License/Date/Cost/Cyl Percentage errors of omissions, multiple markings, out of range, not read by scanner, etc. as marked by individual mechanic
Average Counts/CO and HC	Mean CO and HC readings as obtained from the total of all first emissions tests
Pass/Fail Rates	(shown as percentage)
P/1	Pass first test emission levels
F/V	Failed visual inspection (before first test)
F/E1	Failed standards on first reading of CO and/or HC
F/CO	Failed standard on first CO reading
F/HC	Failed standard on first HC reading
F/2	Failed for any reason on retest emissions levels
F/E	Failed emissions only (will apply to 1982 autos)

SPECIAL REPORT
STATISTICS OF FIRST FAILURES

COLORADO DEPARTMENT OF HEALTH

AIR PROGRAM

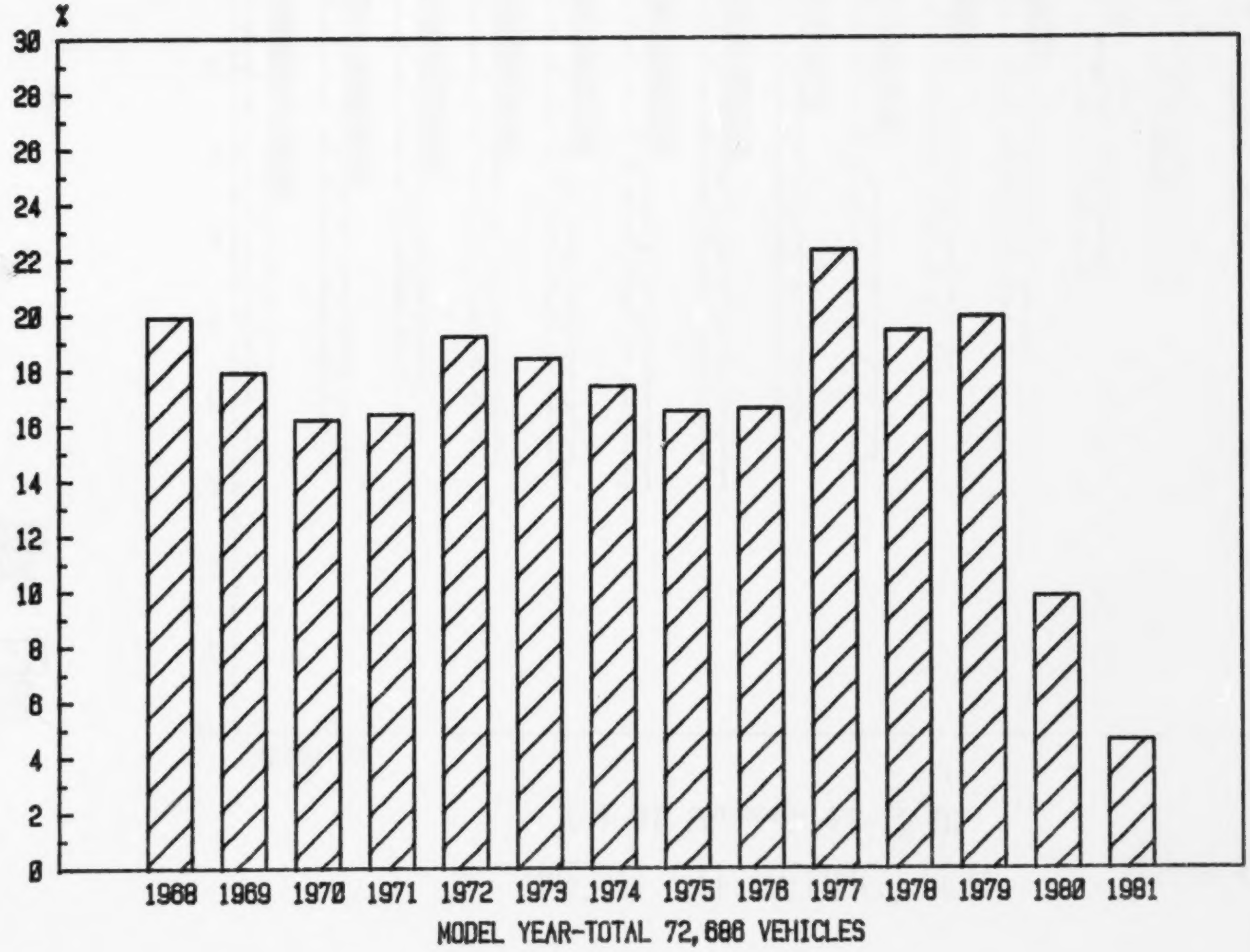
REPORT DATE
09/28/81

MODEL YEAR	TOTAL TESTS	TOTAL RE-TESTS	FAIL RATE	FIRST CO MEAN	RETEST CO MEAN	CORED ------ 1ST CO	MEAN CO REDN	FIRST HC MEAN	RETEST HC MEAN	HCRED ------ 1ST HC	MEAN HC REDN
68	598	112	18.7	6.1446	3.2634	46.890	2.9	1427.9	818.59	42.672	609
69	941	167	17.7	6.6371	3.4808	47.555	3.2	1296.5	688.10	46.927	608
70	1142	164	14.4	6.1226	3.2244	47.336	2.9	1259.9	723.62	42.565	536
71	1350	227	16.8	7.0291	3.2233	54.143	3.8	1169.1	649.14	44.476	520
72	1806	351	19.4	6.7433	3.0353	54.988	3.7	1105.8	537.42	51.402	568
73	2139	376	17.6	6.8811	2.8915	57.979	4.0	1046.7	510.36	51.241	536
74	2450	406	16.6	7.0251	3.1054	55.796	3.9	1014.5	531.84	47.574	483
75	1894	311	16.4	6.1113	2.5566	58.166	3.6	937.39	466.55	50.229	471
76	2530	424	16.8	6.6302	2.8460	57.075	3.8	880.06	446.49	49.266	434
77	2603	568	21.8	5.2741	1.9342	63.327	3.3	754.74	367.98	51.244	387
78	3258	663	20.3	5.3003	1.8332	65.414	3.5	672.22	332.76	50.498	339
79	3515	725	20.6	4.4539	1.5774	64.585	2.9	588.69	287.18	51.217	302
80	2851	259	9.1	4.5954	1.1529	74.912	3.4	498.64	215.17	56.849	283
81	1602	72	4.5	4.0347	1.0528	73.907	3.0	526.21	174.76	66.788	351
82	41	0	0.0	M	M	M	M	M	M	M	M
TOTAL	28720	4825	16.8	5.8309	2.3740	59.286	3.5	865.27	437.23	49.469	428

PASS/FAIL RATES

% Failing First Test

FIGURE 1

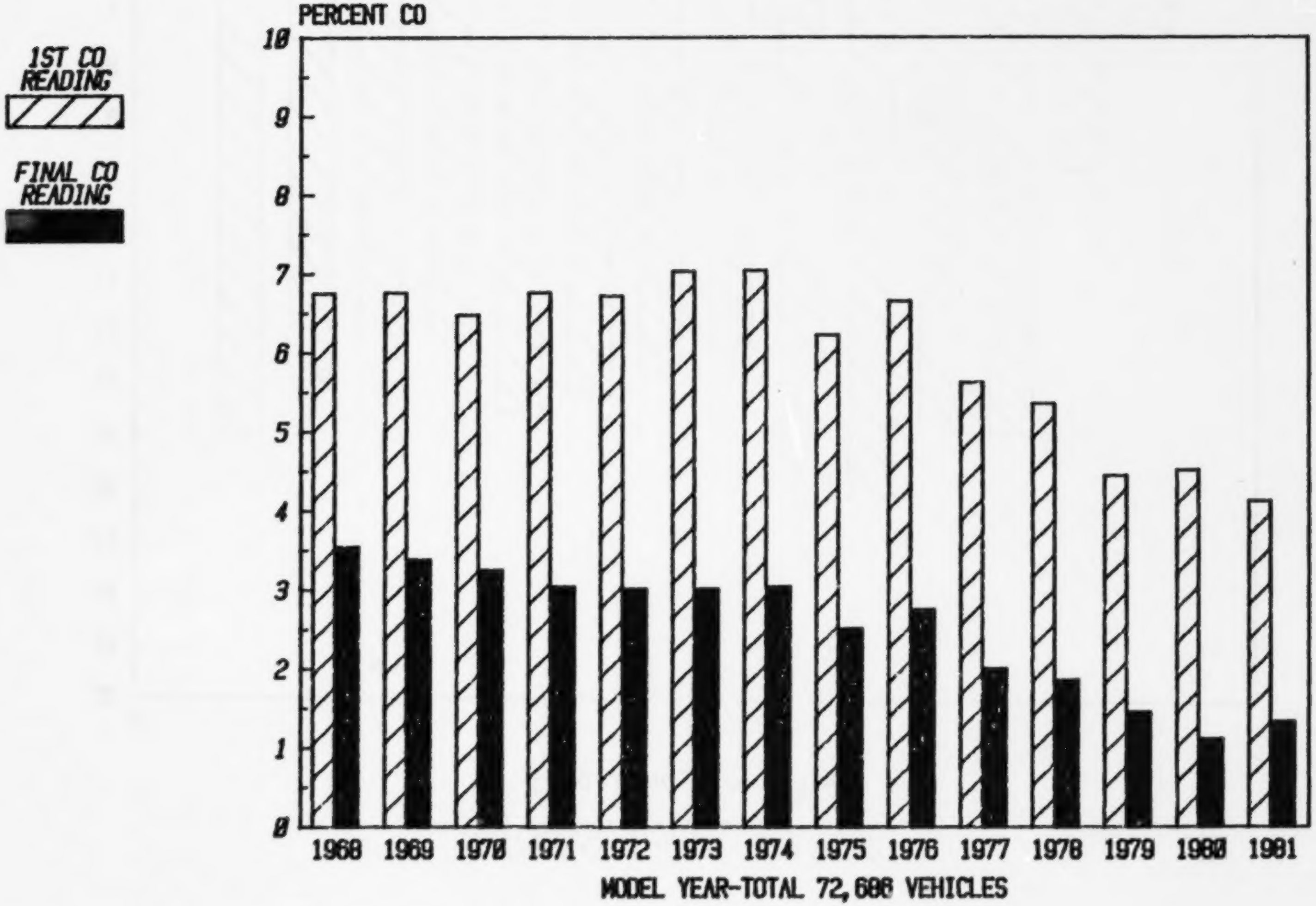


11/12/81

MEAN CO REDUCTION

FIGURE 2

7-1-81 through 11-12-81

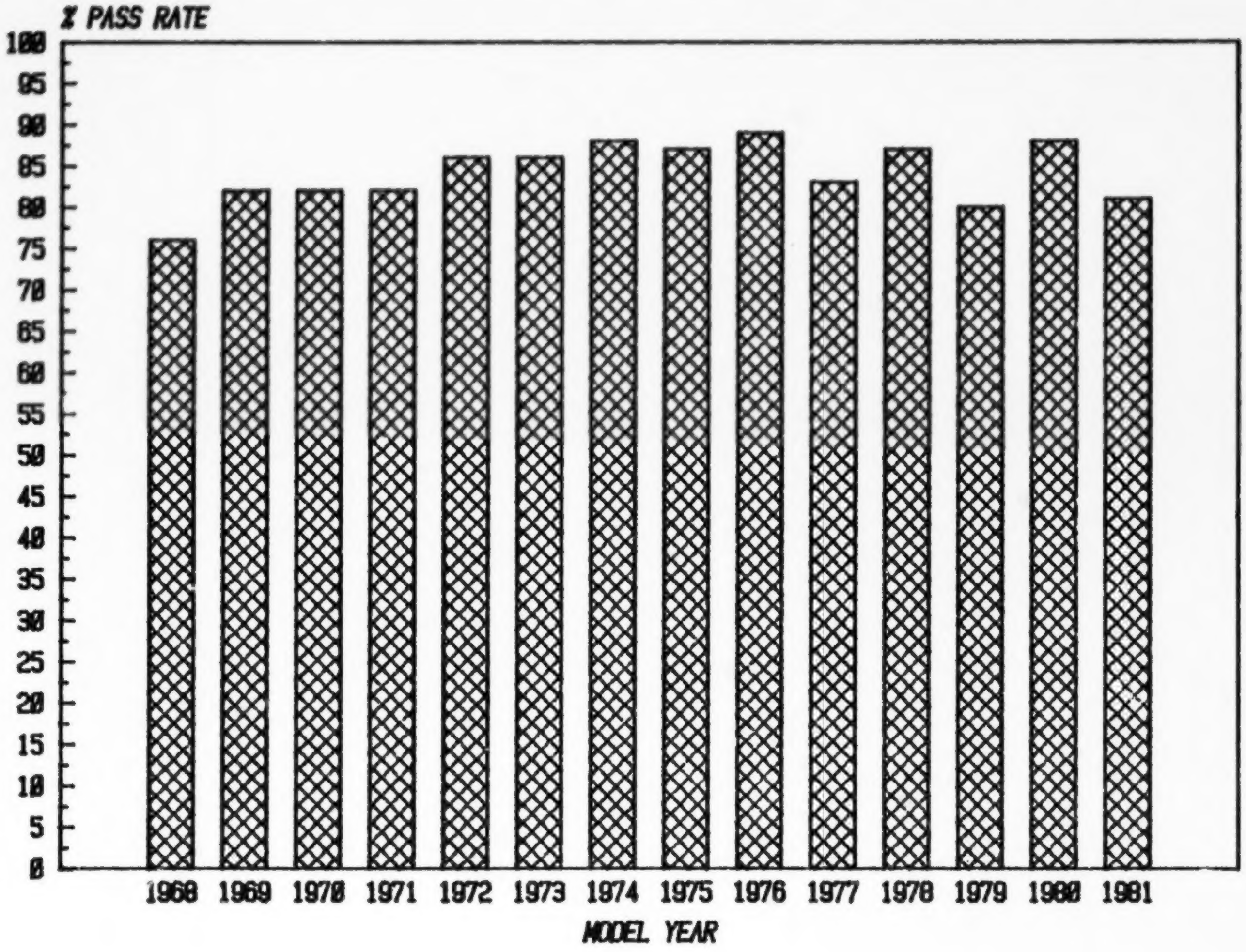


11/12/81

FIGURE 3

% CARS PASSING AFTER ADJUSTMENTS

11,209 Vehicles



11/18/81

APPENDIX H

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The following text is from SPSS, Statistical Package for the Social Sciences, Second Edition, by Norman H. Nie, C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale H. Bent (McGraw-Hill, copyright 1975, by SPSS, Inc. eighth printing), pp. 11-19. It is included in the report to provide a more comprehensive description of the capabilities of SPSS for individuals not acquainted with the package. It is reproduced with permission of SPSS, Inc., 444 North Michigan Avenue, Suite 3300, Chicago, IL 60611.

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reduction that locates fewer underlying dimensions (higher-order variables) out of a larger pool of variables in which no distinction has been made between independent and dependent variables. *Canonical correlation* is in some respects a combination of the two alternate multivariate techniques. It contains data reduction capabilities similar to factor analysis, but, having required the user to divide the variables into two sets, also assesses the relationship between the two sets of factors (called *canonical variates).*

In this way, the researcher is able to conveniently simplify and analyze the relationship between a large number of independent variables and a large number of dependent variables. More precisely, canonical correlation analysis takes as its basic input two sets of variables, each of which can be given theoretical meaning as a set, and extracts linear combinations of the variables within each set; each linear combination maximally correlates with a corresponding linear combination from the other set. These linear combinations are the canonical variates and come in associated pairs. Thus, the higher-order dimensions are created not on the basis of accounting for the maximal variance within one set of variables (as in factor analysis), but on the basis of accounting for a maximum amount of the relationship between the two sets of variables.

Input to the SPSS CANCORR procedure can be either raw data or a correlation matrix. The user may specify the number of pairs of canonical variates to be extracted and the significance level required for extraction. The procedure automatically outputs the canonical correlations, along with tests of their statistical significance, and the coefficients of the canonical variates. CANCORR will optionally punch or write the values of the canonical variates for all cases in the file. These variates can be reentered into SPSS as new variables on a subsequent run.

We have described the principal statistical procedures available within the SPSS system. It is important to realize, however, that these procedures can be executed in any sequence, or repetitively in the course of a single run or session with the computer. Thus the user may elect to perform some crosstabulations, do a multiple regression, and then do some correlations upon the same file of data in a single run. Also, the procedures described share the general capabilities of SPSS for file handling, variable manipulation, and so forth, so that they constitute a sequence of steps available to the user in any order that makes sense in the context of the problem. In Sec. 1.3 we discuss some of the general capabilities of SPSS that are available in conjunction with any statistical procedure the user may specify.

1.3 AN OVERVIEW OF THE OPERATION OF SPSS

In this section we present a summary of the salient capabilities of SPSS, together with examples. In subsequent chapters these features, and the manner in which the SPSS system executes them, are discussed in greater detail. For the moment our purpose is to give the user an overview of how the system operates, and to inform him of what he can and cannot accomplish with it.

1.3.1 SEQUENCING CALCULATIONS

SPSS is driven through its various functions by a sequence of *control cards*[1] that the user must prepare. The process is illustrated in Fig. 1.1. There is a control program in SPSS whose sole function is to read control cards, decode them, and cause the appropriate function called for by the control card to be executed. The control program causes the function to be performed by passing control to the appropriate subprogram, which then performs the function and passes control back to the control program, which then reads another control card, etc. This calculation sequence is carried out automatically by SPSS, and the details of how the control program and subprograms operate need be of no concern to the user. The important thing for the user to

---

[1] Throughout this text, the word *card* is taken to refer to an 80-character record recognizable by the computer. In addition to implying the usual meaning (80-column IBM-card format), card may refer to card-image records entered via a remote terminal, etc.

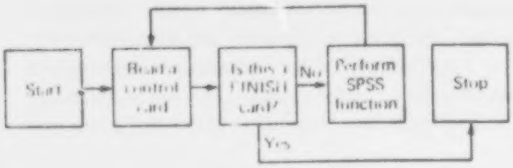


FIGURE 1.1 Program sequencing in SPSS.

realize is that SPSS processes control cards in sequential order. It is up to the user to arrange the control cards so that the system will perform actions in the intended order.

The control cards themselves must be prepared in a particular format so that they are recognizable to the system. There are over 75 different types of control cards in all, and the rules for preparing these cards are discussed in detail in subsequent chapters. An attempt has been made to define the format of the control cards so that they correspond closely to the way the user conceives the problem at hand. Thus, the information entered on these cards consists of a quasinatural language for the description of data-analysis procedures. *In order to use SPSS, it is necessary that the user learn this language.* This is not as formidable a task as it may sound, since an attempt has been made to define the control cards so that they all have similar formats and a minimum of rules is imposed on the user. The user is free to choose names and labels that are natural to the problem at hand.

1.3.2 ENTERING AND PROCESSING DATA

Data may be entered into SPSS in a variety of ways. The simplest and perhaps the most common way is to punch the data on cards and to enter these cards along with the SPSS control cards, which instruct the system on the processing of the data. Some of the SPSS control cards define and describe the data while other types cause specific calculations to be executed. Data is organized within the SPSS system in units called *files*. A file consists of the user's data along with associated information (entered on SPSS control cards) describing and defining the data. Once entered, any such file may be permanently stored for future processing as an SPSS *system file* on tape, disk, or other input-output medium.

In Example 1.1, we show the data and the control cards that the user would have to prepare in order to begin to analyze the data from a hypothetical study of the political party preference of 20 college professors. In this example, the data has been punched on 20 cards (one corresponding to the data record of each professor) and is placed in the card deck directly following the READ INPUT DATA card. The data has been prepared in fixed-column format so that each item of information for each professor is entered in precisely the same position on his data record. In this example, the faculty member's identification number occupies the first four card columns of every case. Party preference occupies column 6, and so forth.

The data-definition control cards that provide the system with information describing the data required for processing are enclosed within a bracket and so designated. The first of these cards, the FILE NAME card, simply names the set of data for future reference. The user may also provide an extended label for the data on this card. On the VARIABLE LIST card the user names each of the variables in the file of data. These user-selected variable names become permanently associated with the corresponding variables in the file, and all future processing is accomplished by reference to these names. The type of the variables and their location on the data records is specified on the INPUT FORMAT card[1] and the number of cases (professors in

---

[1] Readers familiar with Fortran will recognize that the format specifications of the INPUT FORMAT card are a subset of the Fortran format list.

```
                    1               16
                    RUN NAME        DEFINE, CROSSTABULATE, AND THEN SAVE AN SPSS SYSTEM FILE
                    FILE NAME       FACSTUDY,SURVEY OF FACULTY PARTY PREFERENCES
                    VARIABLE LIST   PROF,PARTYPRF,AGE,SEX,RELIGION
                    INPUT FORMAT    FIXED (F4.0,1X,A1,1X,F2.0,1X,A1,1X,F1.0)
                    N OF CASES      20
                    INPUT MEDIUM    CARD
                    VAR LABELS      PROF,FACULTY MEMBER'S IDENT/
Data-definition                     PARTYPRF,POLITICAL PARTY PREFERENCE/
     cards                          AGE,AGE IN YEARS
                    VALUE LABELS    PARTYPRF ('C')CONSERVATIVE ('L')LIBERAL ('S')SOCIAL CREDIT
                                             ('N')NEW DEMOCRAT ('R')NOT GIVEN/
                                    SEX ('M')MALE ('F')FEMALE/
                                    RELIGION (1)PROTESTANT (2)CATHOLIC (3)JEWISH (4)OTHER
                    MISSING VALUES  PARTYPRF ('R')/ AGE (0)
                    PRINT FORMATS   PARTYPRF SEX (A)
Task-definition     CROSSTABS       TABLES= SEX BY PARTYPRF
     cards          OPTIONS         3,5
                    STATISTICS      1,3
                    READ INPUT DATA
                    1912 C 43 M 1
                    1834 M 26 M 1
                    2786 L 35 F 2
                    2576 R 50 M 1
                    1633 N 61 F 2
                    2159 L 31 F 3
                    2634 L 45 F 3
                    1582 C 56 M 1
                    2222 S 37 F 2
     Data           1768 N 45 M 4
    records         2651 S 30 M 2
                    2842 S 44 M 1
                    1899 N  0 F 2
                    2011 C 38 M 1
                    2359 L  0 F 2
                    1975 L 35 M 1
                    2488 C 42 M 2
                    2113 N 36 F 4
                    1313 L 29 M 4
                    2296 L 39 F 3
                    SAVE FILE
                    FINISH
```

EXAMPLE 1.1 Control cards and data used to enter data, perform a crosstabulation, and save a file of 20 cases and 5 variables.

this instance) is indicated on the N OF CASES card. The fact that the data are to be entered on cards is indicated on the INPUT MEDIUM control card. If the data were being entered into the system from some other input medium, the INPUT MEDIUM card would have specified a keyword other than CARD (TAPE or DISK, for example). If this were the case, the 20 data cards would not have appeared in the deck as shown in Example 1.1. The PRINT FORMATS specifies the printing format of the variables and is required only when there are variables in the file that contain nonnumeric characters.

The next three types of cards provide SPSS with additional information frequently used during processing. These cards are optional, however, and need only be prepared if the user wishes to take advantage of certain features available within SPSS. The MISSING VALUES card enables the user to designate up to three values for each variable in the file to be treated as missing. These values are specially treated during analysis, and each statistical program has a number of user-selected options for processing missing values. Given the frequency of missing data in social science research, this card is almost always prepared, although it is optional. The optional VAR LABELS cards permit the user to associate an extended label with any or all the variables in the file. These labels are automatically printed on all tables and reports where applicable. The VALUE LABELS cards serve an identical function for the individual values of the variables and are also optional.

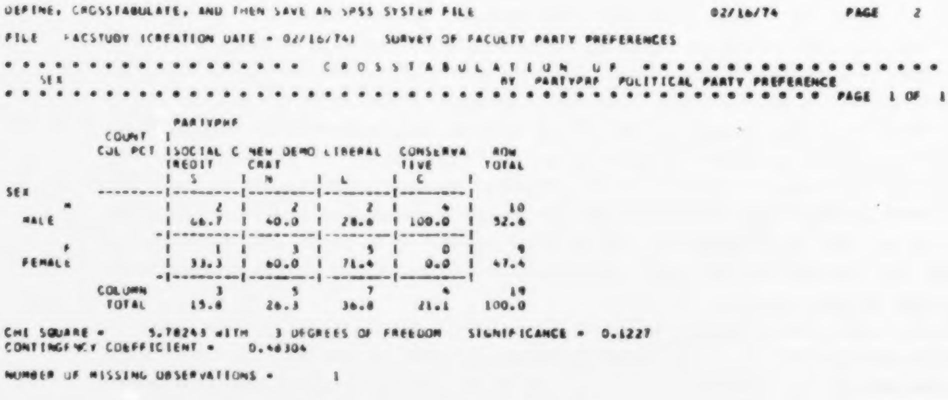
The data-definition cards need be prepared and entered only once, and the information on them can be permanently saved along with the data as an SPSS system file. The SAVE FILE control card directly following the last data card causes one of these specially formatted system files to be created on an output medium of the user's choice. Once a system file has been retained, the information initially entered on these cards is automatically passed from the file to the system along with the data whenever processing is desired. System files may be created for storage during any processing run by inserting a SAVE FILE card in the control-card deck. Thus a special run to generate the file is not required. Furthermore, while SPSS system files are permanent, they are not immutable, and updated files may be created on any subsequent run.

While there are many advantages (to be discussed later) to generating system files, the user may continue to input the data directly from cards or from any type of raw-input-data file, and submit the control cards required to define the data on each processing run, that being the method used with most statistical programs. The control cards required to process the data from cards, tape, or disk files are identical (in kind and number) to those required to create a file for storage as an SPSS system file. In the latter case, the user simply inserts a SAVE FILE control card before the FINISH card.

While one need define a file of data only once, a new set of calculations or tasks will be defined on each processing run. The SPSS system is instructed in the execution of the statistical computations by means of a set of *task-definition* cards. The task defined in Example 1.1 calls for a single table to be computed (using subprogram CROSSTABS), crosstabulating sex by party preference. The CROSSTABS procedure card activates the crosstabulation subprogram, and the OPTIONS and STATISTICS cards provide the CROSSTABS subprograms with additional detailed specifications for building the tables. The OPTIONS card enables the user to control the direction of the percentaging of the table, the processing of missing values, the printing of labels, etc. The desired table statistics, in this case chi-square and the contingency coefficient, are selected by number on the STATISTICS card. Figure 1.2 reproduces the printed output computed for this run.

The remaining four SPSS control cards in Example 1.1 serve simple but special functions in the system. The RUN NAME card, which may contain any message of the user's choice, identifies the run, and the message contained on it is reprinted on the top of each page of printed output generated by the run (see Fig. 1.2). The READ INPUT DATA card informs the system that the user has finished defining the file and the first statistical task, and the system is ready to begin reading the data into the computer. The SAVE FILE card previously mentioned causes the file to be permanently saved as an SPSS system file, and the FINISH card simply informs SPSS that the current run or session is completed.

The example presented shows how to enter raw data into the SPSS system and retain it for future processing while performing a calculation. On any subsequent run the user can retrieve this file automatically, and the variable names, formats, labels, etc., originally entered by the data-definition cards are passed from the file, along with the data, whenever processing is desired. Beyond the obvious advantages of automatic storing and retrieving of what may be



```
DEFINE, CROSSTABULATE, AND THEN SAVE AN SPSS SYSTEM FILE                         02/16/74        PAGE    2

FILE   FACSTUDY (CREATION DATE = 02/16/74)    SURVEY OF FACULTY PARTY PREFERENCES

* * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * *
    SEX                                                            BY  PARTYPRF  POLITICAL PARTY PREFERENCE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * PAGE  1 OF  1

                      PARTYPRF
           COUNT   I
           COL PCT ISOCIAL C NEW DEMO LIBERAL  CONSERVA   ROW
                   IREDIT    CRAT              TIVE       TOTAL
                   I  S     I  N     I  L     I  C     I
SEX        --------I--------I--------I--------I--------I
       M           I     2  I     2  I     2  I     4  I    10
  MALE             I  66.7  I  40.0  I  28.6  I 100.0  I  52.6
                  -I--------I--------I--------I--------I
       F           I     1  I     3  I     5  I     0  I     9
  FEMALE           I  33.3  I  60.0  I  71.4  I   0.0  I  47.4
                  -I--------I--------I--------I--------I
           COLUMN        3        5        7        4       19
            TOTAL     15.8     26.3     36.8     21.1    100.0

CHI SQUARE =     5.78243 WITH   3 DEGREES OF FREEDOM   SIGNIFICANCE =  0.1227
CONTINGENCY COEFFICIENT =    0.48304

NUMBER OF MISSING OBSERVATIONS =       1
```

FIGURE 1.2 Crosstabulations table produced by example run 1.1.

large amounts of complicated file-defining information, the processing speed from these system files is faster than that achieved with raw-input-data files in BCD form.[1] The conversion of data from BCD to internal or SPSS system file representation also greatly facilitates the user's ability to permanently recode variables and generate new scales and indexes through variable transformations, without concern for card and column locations of the new or recoded variables.

In the following respect, the files are permanent, but not immutable. The data, or any of the documenting information, may be added to, deleted, or altered at the user's will, and a new or updated file may be retained. Additional variables can be added to the file as well as additional cases; labels may be added or altered; new variables or scales can be created from existing ones; and documenting messages may be saved in the file. In short, the system file becomes a permanent self-documenting entity, and the user need only remember the name of the file and the order of the variables within. Even this information, if forgotten, can be retrieved easily.

The most important aspect of system files is the potential effect they can have (if properly used) on the interaction between researcher and data during day-to-day analyses. With a complicated data file, it will take considerable time to prepare and debug the initial run that defines the file. However, once this has been accomplished, massive runs taking a long time to plan and prepare need not and probably should not be made. With a system file the researcher can begin to explore particular themes and hypotheses, submitting frequent runs requiring little card preparation, and thus the likelihood of control-card errors is minimized.

Now that we have saved the example file called FACSTUDY a run exploring the relationship between religion and party preference, controlling for the effects of sex, can be made with the control cards of Example 1.2. The GET FILE card (the only control card not previously introduced) causes all the data and required information from the file named on the card to be read into the computer.

```
1               10
RUN NAME        FIRST EXAMPLE PROCESSING FROM A SYSTEM FILE
GET FILE        FACSTUDY
CROSSTABS       TABLES = RELIGION BY PARTYPRF BY SEX
OPTIONS         3,5
STATISTICS      1,2,3
FINISH
```

EXAMPLE 1.2 Control cards required to produce crosstabulations from SPSS system file saved on the previous run.

As shown in Fig. 1.3, the output from this run is two completely labeled subtables displaying the relationship between religion and party preference for male and female faculty members. Comparable runs using many different types of statistical procedures could be made as the analysis progresses.

Each of the control cards discussed above, as well as many other cards which perform a variety of different functions in the system, are presented in great detail in the following chapters, and the reader should not be at all concerned if he feels that he only partially understands the procedures and functions already discussed. The sole purpose of this introductory section is to provide the user with a brief overview of the capabilities of SPSS. File handling and other general capabilities of SPSS are briefly described in the following sections.

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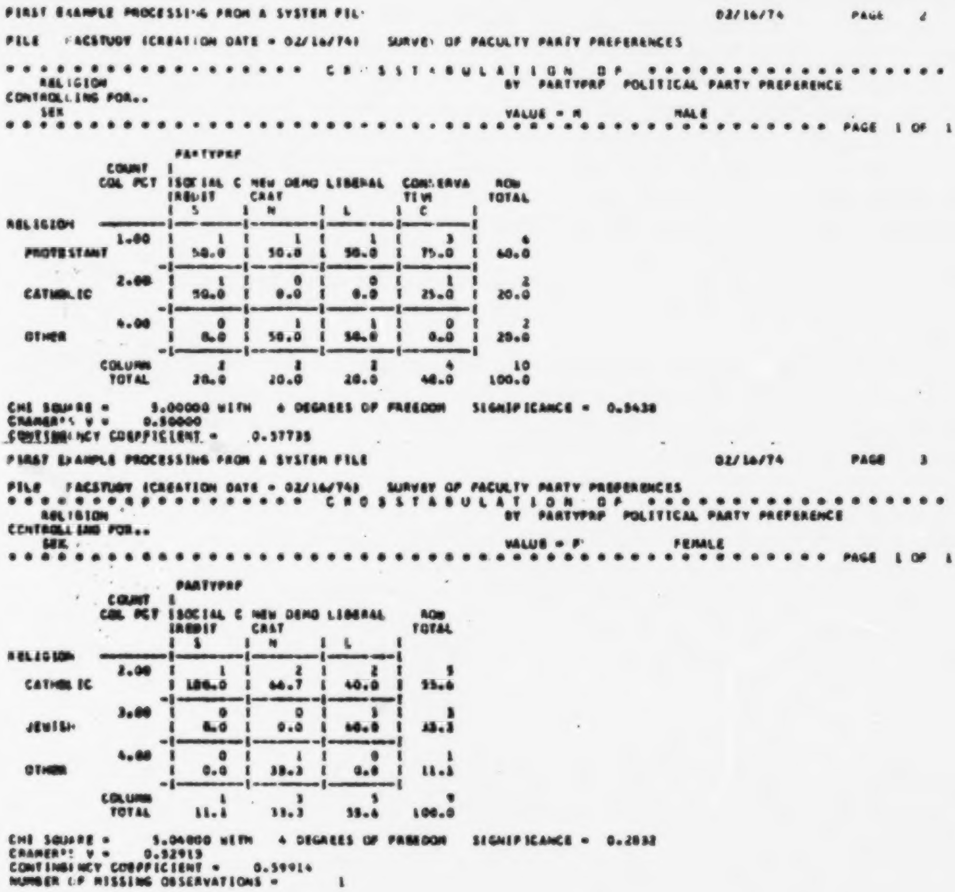
[1] For those unfamiliar with the terminology, BCD stands for binary-coded decimal and corresponds to the recording scheme normally used to punch data onto cards. The BCD recording scheme is one in which a single card column is used to represent a single digit or character. The binary recording scheme used in SPSS system files is also acceptable as raw input to SPSS, but is rarely encountered. Other recording schemes such as column binary or multiple punching cannot be directly input to SPSS.



```
FIRST EXAMPLE PROCESSING FROM A SYSTEM FILE                                02/16/74        PAGE    2

FILE   FACSTUDY (CREATION DATE = 02/16/74)   SURVEY OF FACULTY PARTY PREFERENCES

* * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * *
    RELIGION                                                  BY  PARTYPRF  POLITICAL PARTY PREFERENCE
CONTROLLING FOR..
    SEX                                                       VALUE = M          MALE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * PAGE  1 OF  1

                    PARTYPRF
           COUNT  I
         COL PCT  ISOCIAL C NEW DEMO LIBERAL   CONSERVA   ROW
                  IREDIT    CRAT               TIVE       TOTAL
                  I  S     I  N      I  L      I  C      I
RELIGION  --------I--------I---------I---------I---------I
            1.00  I     1  I      1  I      1  I      3  I      6
  PROTESTANT      I  50.0  I   50.0  I   50.0  I   75.0  I   60.0
                 -I--------I---------I---------I---------I
            2.00  I     1  I      0  I      0  I      1  I      2
  CATHOLIC        I  50.0  I    0.0  I    0.0  I   25.0  I   20.0
                 -I--------I---------I---------I---------I
            4.00  I     0  I      1  I      1  I      0  I      2
  OTHER           I   0.0  I   50.0  I   50.0  I    0.0  I   20.0
                 -I--------I---------I---------I---------I
          COLUMN        2         2         2         4        10
           TOTAL     20.0      20.0      20.0      40.0     100.0

CHI SQUARE =     5.00000 WITH   6 DEGREES OF FREEDOM   SIGNIFICANCE =  0.5438
CRAMER'S V =    0.50000
CONTINGENCY COEFFICIENT =    0.57735
FIRST EXAMPLE PROCESSING FROM A SYSTEM FILE                                02/16/74        PAGE    3

FILE   FACSTUDY (CREATION DATE = 02/16/74)   SURVEY OF FACULTY PARTY PREFERENCES
* * * * * * * * * * * * * * * * *   C R O S S T A B U L A T I O N   O F   * * * * * * * * * * * * * * * * *
    RELIGION                                                  BY  PARTYPRF  POLITICAL PARTY PREFERENCE
CONTROLLING FOR..
    SEX                                                       VALUE = F          FEMALE
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * PAGE  1 OF  1

                    PARTYPRF
           COUNT  I
         COL PCT  ISOCIAL C NEW DEMO LIBERAL     ROW
                  IREDIT    CRAT                 TOTAL
                  I  S     I  N      I  L      I
RELIGION  --------I--------I---------I---------I
            2.00  I     1  I      2  I      2  I      5
  CATHOLIC        I 100.0  I   66.7  I   40.0  I   55.6
                 -I--------I---------I---------I
            3.00  I     0  I      0  I      3  I      3
  JEWISH          I   0.0  I    0.0  I   60.0  I   33.3
                 -I--------I---------I---------I
            4.00  I     0  I      1  I      0  I      1
  OTHER           I   0.0  I   33.3  I    0.0  I   11.1
                 -I--------I---------I---------I
          COLUMN        1         3         5         9
           TOTAL     11.1      33.3      55.6     100.0

CHI SQUARE =     5.04000 WITH   4 DEGREES OF FREEDOM   SIGNIFICANCE =  0.2832
CRAMER'S V =     0.52915
CONTINGENCY COEFFICIENT =    0.59914
NUMBER OF MISSING OBSERVATIONS =        1
```

FIGURE 1.3 Crosstabulation tables produced by example run 1.2.

1.3.3 SUBFILES

Data entered into the SPSS system may be substructured into groups called *subfiles*. Subfiles may be sampling points such as cities; they may be national samples in crossnational survey research; they may consist of data from different time trials or experimental treatments. Subfiles, then, have all of the characteristics usually associated with like samples in statistical analysis. In the SPSS system, the subfile identifier variable (SUBFILE) can be used as a control variable for those statistical subprograms calculating like-sample test statistics, such as analysis of variance. The subfile structure may also be used for more general types of comparative analysis whenever the researcher has two or more like samples. The same relationship, for example, can be examined simultaneously in each of the subfiles.

Once the subfile structure has been created, individual subfiles may be selected for processing, combinations of subfiles may be processed together, or the subfile structure may be ignored altogether—in which case, the data is treated as a unified file. The user controls the manner in which the subfiles are processed in each individual task. At the end of a run, the user may request that cases in the file be sorted and that a new subfile structure be defined on the basis of the outcome of the sort. In this way, the basic subfile structure of the file may be altered at the user's will.

1.3.4 MISSING DATA

It is a common occurrence in social science research to find that for one reason or another it has been impossible to obtain a complete set of data for every case in the file. Such a situation would occur if a respondent refused or neglected to answer a question on a questionnaire, or if the response was not entered correctly on the data sheets. SPSS has a number of features for processing such missing data. Each variable may have up to three values that are designated as *missing*. The choice of these values is totally a matter of the user's discretion, and is used to designate the reason why proper data has not been obtained. For example, the user may elect to use the code 0 for *not applicable*, 8 for *don't know*, and 9 for *refused to answer*. These missing-data indicators may be defined by the use of a MISSING VALUES control card and retained with the other information in a SPSS system file. Each of the statistical subprograms contains a number of options for processing missing data, and the user may select whichever option seems best suited to the particular analysis situation.

1.3.5 RECODING DATA

In order to organize data for analysis, the user first determines the *variables* to be dealt with. The term variable means a certain attribute which can be determined or measured, and it must be carefully distinguished from the term *variable value* (or *value*), which means the value determined or measured for a variable in a particular case. After listing the variables, the user next decides the way values of each variable will be coded. When the data is to be processed with the computer, the way the coding system is devised can make a substantial difference in the ease with which the user can cause the computer to carry out the desired computations.

Frequently, the coding system originally used to record the data is not the most convenient for use in all parts of the analysis. A provision has been made in SPSS for the user to change the coding system *after* entering the data in its original form into the system. The value of any or all the variables can be changed at the user's will by means of the RECODE process. Selected values of variables may be replaced with new values, and continuous variables may be classified into discrete categories. The RECODE process can be used to temporarily alter values of the variables in conjunction with a run of a particular statistical subprogram, or it may be used to effect a permanent recoding of variables in the file.

1.3.6 VARIABLE TRANSFORMATIONS

A wide variety of variable transformations can be accomplished in SPSS by means of simplified Fortranlike statements constructed by the user. The allowable types of transformation are two types: conditional or unconditional. The unconditional transformations, defined by COMPUTE control cards, cause a new variable to be constructed from the values of other variables. For example, the control card

```
1              16
COMPUTE        A=B+C
```

causes a new variable, named A, to be defined. The values of this new variable are determined by adding the values of the existing variables B and C. Conditional transformations are defined by the IF card. The IF card enables the user to test if a certain condition is true; if it is true, a transformation is performed. Thus, the control card

```
1              16
IF             (D EQ 1) A=B+C
```

causes SPSS to examine the values of the variable D. If for a particular case the variable D assumes the value 1, a new value for variable A is computed by adding the values of variables B and C.

Transformations can be used to normalize or in some other way alter the distribution of variables as well as to construct scales or indices from two or more existing variables in a file. The transformation process, like the recoding process, can be used to create a permanent file of transformed variables, or it may be used to create temporary variable modifications during a given run of SPSS.

A large number of repetitive transformations can be executed with a minimum of card preparation by using the special repeat transformation. Sums of the occurrence of certain values across a number of variables may be efficiently computed by means of the COUNT transformation card. Finally, a standard procedure for handling and assigning missing values for variables created by any of the above types of variable transformations may be accomplished by the ASSIGN MISSING command.

1.3.7 SAMPLING, SELECTING, AND WEIGHTING DATA

A random sample of the cases in a file may be obtained, specific cases may be selected for processing, and the cases in the file may be weighted. The user is able to specify all the conditions and criteria for accomplishing sampling, selecting, and weighting during any processing run. As with recoding and variable transformations, sampling, selecting, and weighting may be done in conjunction with a particular computation, or a new file of sampled, selected, or weighted cases may be obtained.

1.3.8 AGGREGATING DATA

Research may involve dual levels of analysis or at least the examination of the impact of some larger unit or institution on the behavior of individuals. Subprogram AGGREGATE permits the researcher to define larger *aggregation units* and to compute *aggregated variables*.

Cases may be sorted into aggregation units on the basis of the values of any variable(s) in the file. Aggregated variables summarize the characteristics of the individuals in each aggregation unit; these variables are the means, standard deviations, percentages, etc., of variables in the file which have been measured at the individual (i.e., lower) level. The aggregated variables, along with aggregation unit identification numbers, are then punched on cards or written on tape or disk, thus forming a new aggregated file.

Such aggregated files can then be input to SPSS or to other statistical programs, thus shifting the level of analysis. Alternatively, subprogram AGGREGATE can produce a set of aggregate characteristics which can be subsequently joined to the individual's data records in the original file. In this way, the user may perform what has come to be known as *contextual* or *compositional analysis*.

1.3.9 FILE MODIFICATION AND MANAGEMENT

SPSS makes available to the user a large number of general housekeeping routines for the management, manipulation, and modification of data files. During any processing run, new variables not currently in the file may be added to the file, providing a powerful facility for merging separate sets of information on the same cases. Similarly, variables deemed to be of no further use to the researcher may be deleted. Additional cases may be added to the file as they become available to a study. Whole new subfiles may be added in a similar way. The cases of a file may be resorted at the user's command for the purpose of aggregation or for the definition of a new subfile structure. Master or archival files containing unusually large numbers of variables can be accessed, merged, and saved, as well as converted into normal SPSS system files for statistical processing.

Specified cases may be printed at the user's request. Missing-data indicators and a variety of labelling information pertaining to individual variables or sets of variables may be altered or updated at the user's request. Finally, for the IBM-user community a special feature has been added, enabling SPSS to read and convert data files distributed in the University of Michigan Survey Research Center's special OSIRIS format.[1]

1.3.10 RETRIEVAL OF DATA FROM THE SYSTEM

All data input into the SPSS system, as well as recoded variables, new variables created by transformation, and file changes accomplished by sampling, weighting, and/or selection may be punched on cards or written in BCD form on a device of the user's choice via the WRITE CASES procedure. The cards or the BCD data files can then be directly input into the user's own programs or into other statistical packages. The user has complete control over the selection of variables to be output and their formats, as well as control over the selection of cases to be output.

File-definition information, such as variable lists, labels, and missing-value codes may be punched on cards in SPSS control-card format by the WRITE FILEINFO procedure, thus facilitating the movement of SPSS files from one type of computer to another.

The SPSS correlation programs permit the user to output correlation matrices in BCD form on cards, tape, or direct-access devices. All the SPSS multivariate routines using correlation coefficients allow the user to input correlation matrices as well as raw data. In addition to saving the user machine time by bypassing the initial correlation step of these multivariate techniques, the *matrix-input* feature allows matrices generated by the user's own program or by other statistical packages to be input into SPSS subprograms; *matrix output* allows for convenient use of matrices by non-SPSS programs as well as by those in the package.

Finally, Z scores, regression residuals, factor-scale scores, and canonical variables may be output. Such variables may be subsequently merged with existing files.

These features enable the user to utilize the file management, data modification, and statistical capabilities of SPSS without becoming a prisoner of the system.

1.3.11 OUTPUT OF RESULTS FROM THE SYSTEM

Since in this general discussion of SPSS and its features we have been concerned mainly with problems of entering information into the computer, the user may well wonder how output is obtained from the system as well. For the most part, printout is provided automatically so the user need not be concerned with how SPSS accomplishes this. Generally, output occurs when the user calls for a particular statistical procedure to be performed upon a file of data. The system then causes the calculations to be made and produces a printed report containing these results on the line printer or other output device. The level of detail that these reports contain depends upon the level of detail provided when the file was defined.

For example, the user may define a variable named POLPREF. The user has the option of also defining an extended label for POLPREF, as well as extended labels for the various values which POLPREF can assume. If these labels are present, they will appear automatically on the output reports. If they are not present, no labelling information appears. The user decides in each case whether it is worth the trouble to enter additional information to make the printed output more fully documented.

There are some subprograms, such as the crosstabulation subprogram CROSSTABS, which allow the user a good deal of latitude in specifying the level of detail to be contained in the printout. The user may elect to use an OPTIONS control card to cause a subprogram to produce the report desired. These options are discussed in those sections specifying the rules for using various subprograms.

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[1] OSIRIS is another widely used package of computer programs designed for the analysis of social science data. The system was developed by the Institute for Social Research, University of Michigan, and the Inter-University Consortium for Political Research.

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